GL04910

GeothermEx, Inc. 901 MENDOCINO AVE. BERKELEY, CA. 94707

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TECHNICAL REPORT

DEEP WELL TEST AND EXPLORATION PROGRAM

for

ORE-IDA NO. 1,

ONTARIO, OREGON

VOLUME 3 - APPENDICES F, G, H, I, J, K

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May 1980

under Sub-subcontract No. ET-78-C-07-1725-GTX, between
CH2M-Hill Central, Inc. and GeothermEx, Inc.

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APPENDIX F

QUALITATIVE ANALYSIS OF WELL LOGS

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QUALITATIVE ANALYSIS OF WELL LOGS

The analysis of the well logs from the subject well was principally performed in the field on November 10 and 11, 1980. It is essentially a well-site analysis and is qualitative. Much additional information can be gained by a thorough, quantitative analysis of the data on a computer.

Table F-1 lists the well logs run in the well, together with other relevant information. All logs listed in Table F-1 were run by Welex. The quality of logs generally is good. However, no direct porosity scale or API unit scale is given for the Neutron Log, thereby making quantitative use of the Neutron Log impossible. Dip logs show dip angle, azimuth and the relative correlation quality for each correlation interval. The Microseismogram-Cased Hole Log also provides casing collar locator, relative neutron response and relative amplitude of the compressional wave. The Fracture Finder-Microseismogram Log also provides self-potential, caliper and shear wave amplitude data. Compensated Density Log-Neutron also provides gamma ray, caliper and density correction ($\Delta\rho$) curves. Compensated Acoustic Velocity Log also presents self-potential, caliper and time depth integrator data. Dual Induction Guard Log provides self-potential, along with deep induction, medium induction and shallow guard logs.

Log No. 25 listed in Table F-1 was prepared by the Energy Well Logging Service. Log No. 26 in Table F-1 was prepared by GeothermEx, Inc. Logs 1 through 24 and 27 in Table F-1 were run by Welex.

The Computer Analyzed Log Systems (CAL) of Welex, listed as log 27 in Table F-1, was not useful for this study. CAL is designed for petroleum wells in sedimentary formation. For tuffs and silicified "siltstones" (Type 3) or basalts and diabase (Type 4) CAL information is practically meaningless, because true matrix properties of these nonsedimentary lithologies are not known. However, these matrix properties can be derived and a complete analysis performed by the aforementioned statistical approach aided by a computer.

The aims of this qualitative analysis were:

1. Identification of lithology
2. Detection of fractures and porous zones
3. Detection and estimation of gas content in formation
4. Estimation of the equilibrium formation temperatures

TABLE F-1

WELL LOGS RUN IN ORE-IDA NO. 1 WELL

	Log Type	Date	Top of Logged Interval (ft)	Bottom of Logged Interval (ft)
1.	Dual Induction Guard Log	9/18/79	925	7,150
2.	"	10/1/79	7,150	7,956
3.	"	11/8/79	8,182	10,053
4.	Compensated Acoustic Velocity	9/18/79	925	7,148
5.	"	10/1/79	7,148	7,952
6.	"	11/8/79	8,182	10,048
7.	Compensated Density Log-Neutron	9/18/79	925	7,250
8.	"	10/3/79	7,150	7,955
9.	"	11/8/79	8,182	10,038
10.	Fracture Finder Microseismogram Log	9/18/79	925	7,148
11.	"	10/1/79	7,148	7,952
12.	"	11/8/79	8,180	10,047
13.	Microseismogram Log-Cased Hole	11/9/79	6,800	8,198
14.	Dip Log	9/18/79	925	7,955
15.	"	11/9/79	8,180	9,931
16.	Temperature Log, Run No. 1	9/18/79	0	7,150
17.	Temperature Log, Run No. 2	9/19/79	0	7,150
18.	Temperature Log, Run No. 3	9/19/79	0	7,150

TABLE F-1--Continued

	Log Type	Date	Top of Logged Interval (ft)	Bottom of Logged Interval (ft)
19.	Temperature Log, Run No. 4	9/20/79	0	7,140
20.	Temperature Log, Run No. 5	10/1/79	0	7,958
21.	Temperature Log, Run No. 6	10/2/79	0	7,958
22.	Temperature Log, Run No. 7	10/2/79	6,000	7,958
23.	Temperature Log, Run No. 8	11/9/79	0	10,053
24.	Temperature Log, Run No. 9	11/10/79	0	9,360
25.	Drilling Log, Mud Log, and Cuttings Log	For the entire drilling period	55	10,055
26.	Cuttings and Core Log of Binocular Microscope Description	For the entire drilled section	30	10,040
27.	Computer Analyzed Log System	Based on Welex logs	6,000	7,900

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Identification of Lithology

From the cuttings log it is seen that the lithologic types encountered in this well can be grouped under four classes:

1. Sandstone
2. Siltstone and claystone
3. Tuffs and silicified "siltstones"
4. Basalts and diabase

In the above classification the silicified "siltstone" type as described in the cuttings log probably represents tuffites. A careful examination of all available well logs allows establishment of a set of diagnostic criteria for each of the lithologic types. Table F-2 presents these criteria. It has been noted that the criteria can be quantified by more detailed study, preferably a computer-based statistically-oriented approach. Time and budget provided for this project did not dictate a detailed log interpretation effort.

Alteration due to hydrothermal or other causes appears to change sharply the log response of the lithologic types in this well. For example, diabase when fresh has a Δt of 45 and 50 μ sec/ft. When hydrothermally altered it increases to as high as 100 μ sec/ft. Similarly, diabase and basalt when fresh display densities in the range of 2.9 to 3.0 gms/cc. When altered, these lithologies display densities as low as 2.45 gms/cc for basalt and 2.80 gms/cc for diabase. Gamma ray declines due to alteration of diabase from 60 to 20 API units in typical cases. Thus it is possible to qualitatively delineate hydrothermally altered zones and, in a quantitative analysis, possibly the extent of hydrothermal alteration. The importance of delineating hydrothermal alteration and measuring its extent may be:

a. in exploration for, purposes of correlation and development of a genetic model for the geothermal system, and
b. in well engineering, if presence of pores or fractures can be correlated to hydrothermal alteration, well completion design decisions may be more precise.

With the help of the log response criteria presented in table F-2, the drill cuttings log, mud log, and particularly the data from the binocular microscope study of the cuttings, the entire well section was divided into individual zones. Each zone has a distinct lithologic description. The advantages of this zonation technique over a section based on drill cuttings alone are many. The most important advantage

TABLE F-2

DIAGNOSTIC CRITERIA FOR LITHOLOGIC TYPES - ORE-IDA NO. 1

Lithologic Type	Drilling Rate	Hole Enlargement	Self-Potential	Gamma Ray	Conductivity
1. Sandstone	High	Sometimes negative enlargement due to mud cake	Moderate	Moderate (80-140 API)	Moderate
2. Siltstone and claystone	Moderate to high	Occasional	None	Moderate (80-150 API)	....
3. Tuffs and silicified "siltstone"	Moderate	Unusual	Low	High (>200 API), off-scale	....
4. Basalts and diabase	Slow	In fractured sections	Low, wandering	Low (20-70 API)	Very low

Lithologic Type	Sonic Travel Time	Bulk Density	Neutron Log Response	Dip Log Response	Other Characteristics
1. Sandstone	Moderate (55-100 μ sec/ft when compacted)	Moderate (2-2.6 gms/cc)	Moderate to low porosity	Excellent correlation quality, numerous correlation intervals	Occasional mudcake buildup
2. Siltstone and claystone	High (100-110 μ sec/ft)	Moderate (2.4-2.6 gms/cc)	High porosity	Excellent correlation quality, numerous correlation intervals	....
3. Tuffs and silicified "siltstone"	High (up to 150 μ sec/ft)	Low 2.4-2. gms/cc)	Low porosity	....	Characteristic high Δt on microseismogram
4. Basalts and diabase	Moderate (45-100 μ sec/ft)	High (up to 3.0 gms/cc)	High porosity	Poor correlation quality and very few correlation intervals	Convective heat flow on temperature log

is that while cuttings data can define lithologic boundaries within a few tens of feet at best because of difference in velocities of cuttings because of differences in densities of lithologies, the log-derived data can be accurate to about one foot. Moreover, erroneous identification of lithology is possible when using cuttings because of their small size. Once the logs can be "calibrated" as to their log responses (Table F-2), log response becomes an accurate tool for lithologic zonation. Plate 5 shows the lithologic zonation in this well as derived from drill cuttings data and log responses. In preparing Plate 5 it was observed that the binocular microscopic study of cuttings (Appendix A) agreed much closer with the log responses than did the well-site drill cuttings report (Log 25 in Table F-1). It should be pointed out that using Appendix A and preferably the thin section petrographic study one can develop a finer "calibration" of log responses to lithology, so that subtler lithologic variations and hydrothermal alterations in the section can be recognized. Thin section petrography is in Appendix B.

Detection of Fractures and Porous Zones

Fractures in geothermal systems can be detected and evaluated with varying degrees of certainty from the various well logs. The most useful evaluation procedure is to combine the fracture detection criteria from various well logs and determine an overall probability of frequency of occurrence and general nature of the fractures in a well. Based on the available well logs, the following fracture detection criteria have been applied to the subject well (Sanyal, et al., 1979). Some are self-evident (1, 2) while others are highly inductive.

1. Drilling Rate - Usually fractured intervals display faster drilling rates.

2. Mud Circulation Data - Most fracture zones cause lost circulation of mud.

3. Drill Cuttings Data - Drill cuttings sometimes show "drusy" quartz indicating partial filling of fractures.

4. Self-Potential - Igneous rock formations do not usually display self-potential unless fractured, when mud-filtration through fractures may give rise to a streaming potential.

5. Conductivity - Igneous rock formations usually display very low conductivity unless fractured. In fracture zones shallow-investigation resistivity logs show higher conductivity because of the presence of mud in fractures.

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6. Separation between Shallow Guard and Induction Logs - In fractured igneous formations, the shallow guard log should show higher conductivity than the induction logs, which have a higher depth of investigation.

7. Hole Enlargement - Fractured sections often show hole enlargement.

8. Three-Arm and One-Arm Caliper Data - When there is an inclined fracture, the hole usually becomes non-circular in cross section, due to preferential hole enlargement in the direction of the fracture. A three-arm caliper gives an average diameter of the well. On the other hand, the one-arm caliper with a pad-mounted device, such as the density tool, tends to give the maximum width of the borehole. This is so because the caliper arm in such a tool is pressed very hard against the borehole wall and when the tool is pulled up during logging the caliper arm tends to align itself and extend in the direction of the maximum width. Thus for a fracture zone the one-arm caliper indicates a larger diameter than the three-arm tool.

9. $\Delta\rho$ Curve - When the caliper log shows that a borehole is smooth but the $\Delta\rho$ curve shows large corrections to the density reading, it may imply either mudcake buildup or the presence of fractures. In igneous lithology, mudcake buildup is not common; hence an unusual value of $\Delta\rho$ in a smooth section of the hole indicates fractures.

10. Neutron and Density Logs - In an igneous formation, fractures usually account for most of the porosity, unless there is vesicular porosity. Hence neutron and density logs should indicate relatively higher porosities in fractured zones.

11. Comparison of Sonic and Density Porosities - In fractured zones, sonic log-derived porosity will be lower than the density log-derived porosity because the sonic log does not "see" most fractures. Unfortunately, in Ore-Ida No. 1 it is difficult to do this comparison because to calculate porosities one needs the properties of the matrix. Even though we have suggested that lithologic zonation in this well was possible, accurate matrix values for each lithology cannot be determined without a more quantitative approach.

12. Compressional Wave Amplitude - Fracture zones cause a reduction in the amplitude of the compressional sonic wave.

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13. Microseismogram - Fracture zones cause interference in sonic waves. As a result, in the full wave-train presentation in the microseismogram, fracture zones are indicated by interference patterns.

14. Rock Strength - The mechanical strength of a rock is proportional to $\rho/(\Delta t)^2$ where ρ is the bulk density and Δt is the travel time of the compressional sonic wave. A rock with high mechanical strength can undergo brittle fracture; a rock with low strength does not usually show brittle fracturing.

Table F-3 lists all suspected fracture zones in Ore-Ida No. 1 with checkmarks for the satisfied criteria. A question mark in Table F-3 implies that it is not clear whether the criterion is satisfied or not. Based on the number of satisfied criteria, we have concluded whether a zone is fractured, probably fractured or possibly fractured.

In the subject well, the fracture zones appeared to be confined to basalts. There are some permeable zones in the sandstone sections in this well which have intergranular rather than fracture porosity. For such zones many of the criteria used in Table F-3 are not relevant.

Detection and Estimation of Gas Content

The mud log in Ore-Ida No. 1 shows significant methane gas concentration above 7,200 feet, primarily in the sedimentary intervals. Considering reported gas shows in several wells in this region, it is possible that this well may have free gas saturation. The usual indication of gas saturation in a well is the fact that neutron log-derived porosity is lower than the density log-derived porosity. However, it is not possible to verify this condition because a) excessive hole enlargement, often greater than 12 inches, renders density log data unreliable, and b) bulk density of the rock matrix cannot be estimated accurately.

Another approach is to calculate the gas saturation from the resistivity data. However, we have no knowledge of the formation water resistivity. Assuming that the SP generated at the permeable sand section at 6,950-7,010 feet is the static SP, without any streaming potential, we can calculate the approximate resistivity of the formation water as 0.07 ohm meters. Assuming a matrix density of 2.70 gms/cc for these silicified sediments, a porosity value (ϕ_D) of about 28 percent for this zone results, which is close to ϕ_N. This estimate is reasonable because the hole is in gauge and the sand is relatively clean.

TABLE F-3

SUSPECTED FRACTURE ZONES

Zone	Criteria 1	2	3	4	5	6	7	8	9	10	11	12	13	14	Remarks
9,985 - 10,010	?			√	√	√						√	√	√	Possibly fractured
9,924 - 9,936					√		√	√		√		√	√	√	Probably fractured
9,792 - 9,806	√			?	√					?		√	√	√	Possibly fractured
9,880 - 9,890	√					√					√	√	√	√	Possibly fractured
9,300 - 9,510												√			Possibly fractured
9,020 - 9,235			√		√	√	√	√		√	√	√	√	√	Fractured
8,970 - 8,990	√				√	√	√			?		√	√	√	Probably fractured
8,730 - 8,840						√	√	√		?		√	√	√	Probably fractured
8,640 - 8,670						√		√				√	√	√	Possibly fractured
8,450 - 8,520			√	√?		√	√	√		?		√	√	√	Probably fractured
8,320 - 8,400					√	√	√	√		?		√	√	√	Probably fractured
8,178 - 8,216			√	√			√						√		Possibly fractured
7,050 - 7,130		√		√	√	?	√	√		?		√	√	√	Fractured
6,950 - 7,010	√		√	√			*			√					Permeable, intergranular
6,580 - 6,670	√		√	√			*								Permeable, intergranular

*Mud cake buildup.

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Assuming the conventional water saturation equation to be valid for this well, we can calculate a water saturation of 24 percent from the resistivity value for this zone (induction resistivity reading used without correction). This indicates 76 percent gas saturation, which appears to be too high to be realistic.

Because of the uncertainties in the calculated water saturation value, we cannot consider the above calculation reliable. In particular, although the hole section in this zone is in gauge, the neutron log-derived porosity appears to be greater than the density log-derived porosity for any reasonable assumed matrix density. This is exactly opposite of what is expected from a relatively clean gas sand. The question of gas saturation may be settled when this section is perforated, stimulated and tested.

In a more detailed analysis, one can calculate the formation water resistivity from log response crossplots and calculate more reliable values of water saturation.

Estimation of the Equilibrium Formation Temperature

Nine temperature logs were run in the subject well (Table F-1). Maximum recording thermometer readings from other logs also provide information about the formation temperature. However, all such data provide transient temperature values. To obtain the equilibrium formation temperature, a geothermal well needs to be shut in for several weeks. There are techniques of calculation of the equilibrium temperature from the transient temperature data, the most common being the Horner technique. In this technique the transient well temperature (T_{ws}) at a specific depth is noted as a function of the time (Δt) since mud circulation in the well stopped. If the total mud circulation time (t_p) before logging is known, then a plot of T_{ws} versus Horner dimensionless time, given by $(t_p + \Delta t)/\Delta t$, is made. According to the theory of the Horner technique, such a plot should be linear. A straight line is fitted through the data points on Horner plot. When extrapolated to a Horner time of unity, this line provides the equilibrium formation temperature (Ti).

It is now established that the conventional Horner technique is not strictly applicable in most practical cases (Roux and Sanyal, 1980). This is because the boundary condition of constant heat flow rate at the wellbore before circulation stops is not realistic. Roux and Sanyal (1980) present theoretical Horner plots for various values of a dimensionless circulation time (t_{pD}), considering the boundary condition of

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constant wellbore temperature before circulation is stopped. This latter boundary condition is more realistic in geothermal wells, where the temperature gradient is very small, due to convection. In most geothermal wells the temperature gradient is steep above the reservoir, but is very small isothermal or reversed within the reservoir. In many practical cases the boundary condition at the wellbore is neither the one assumed in the conventional Horner technique, nor the one assumed by Roux and Sanyal (1980), although closer to the latter. Figure F-1 shows the true Horner plot and the modified Horner plots. It should be noted that the modified Horner plots are curvilinear and functions of t_{pD}.

In Ore-Ida No. 1, the temperature data for depths below 7,960 feet are inadequate for a reliable analysis. Hence, 7,960 feet was chosen to be the deepest point for which a transient temperature analysis was worthwhile. The total circulation time for this depth was 23 hours. Table F-4 shows the relevant numerical data. Maximum recorded temperature from Logs 2, 11 and 5 of Table F-1 and from the Temperature Log Runs #5, #6 and #7 were utilized in this analysis. The data are shown as a Horner plot on Figure F-2. Before the data on Table F-4 and Figure F-2 are analyzed, we are reminded that the analysis will be of limited accuracy because:

1. Circulation was interrupted more than once, thereby invalidating the basic premise of the approach that the well has undergone a single circulation.

2. Exact values of t_p and Δt cannot be ascertained unless precise notations of circulation and logging history are available.

3. Data show much scatter. For example, the two or three maximum recording thermometer values provided with each temperature log differed considerably. In Figure F-2, those data points considered relatively reliable are circled. Only these points have been used for analysis. Why aren't the BHT from the temp logs considered reliable?

   Ah, yes!

4. There may have been a significant convective component in heat flow at this depth and at several other intervals because of either mud filtrate invasion or flow-through colder aquifers. These conditions have not been considered.

Figure F-2 shows that the extrapolated temperature (T^*_{ws}) for a Horner time of unity is 347°F. The t_{pD} is defined as:

$$t_{pD} = Kt/c_p\ \rho\ r_w^2$$

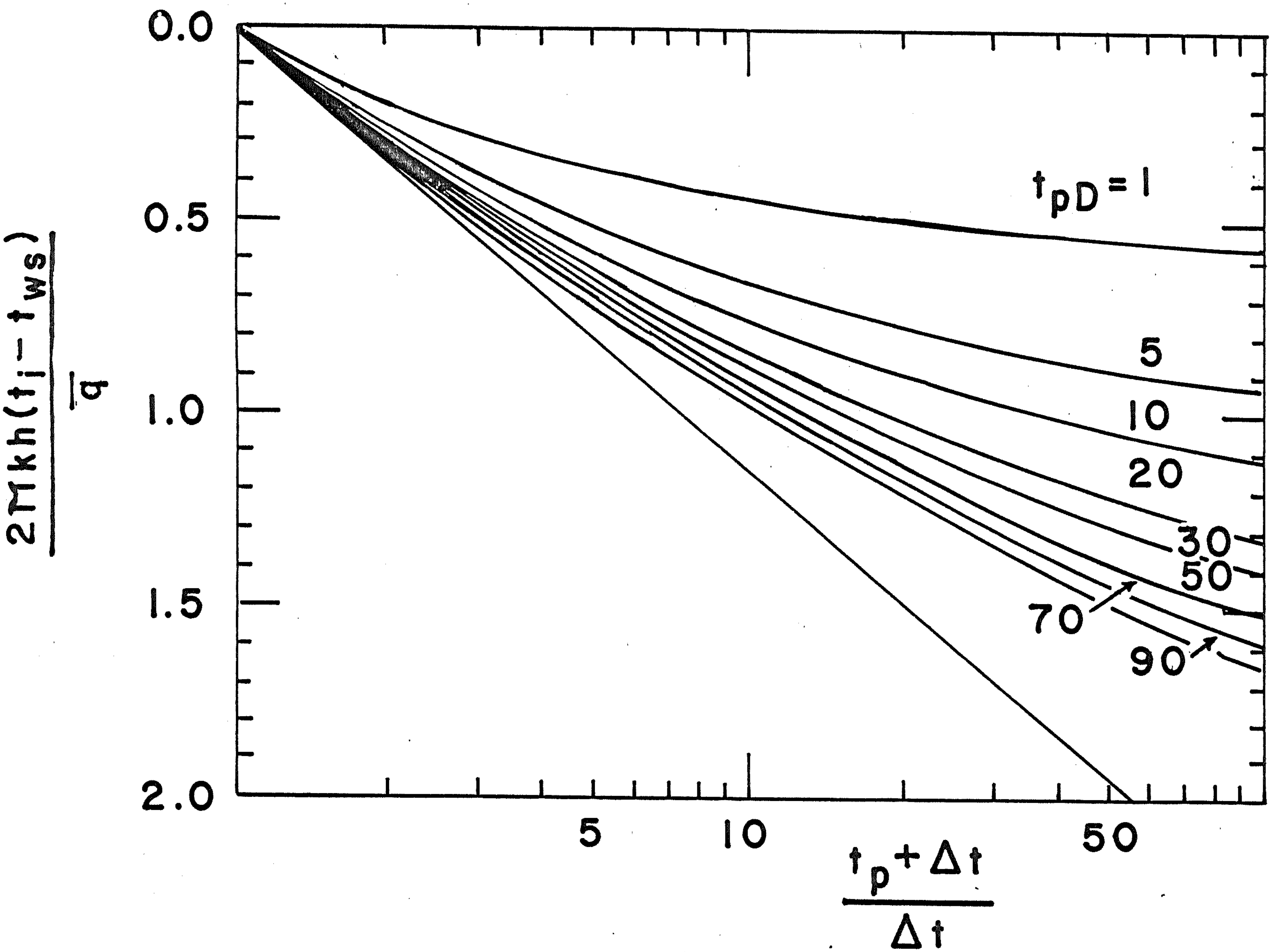

FIGURE F-1

MODIFIED HORNER PLOT

(From Roux & Sanyal, 1980)

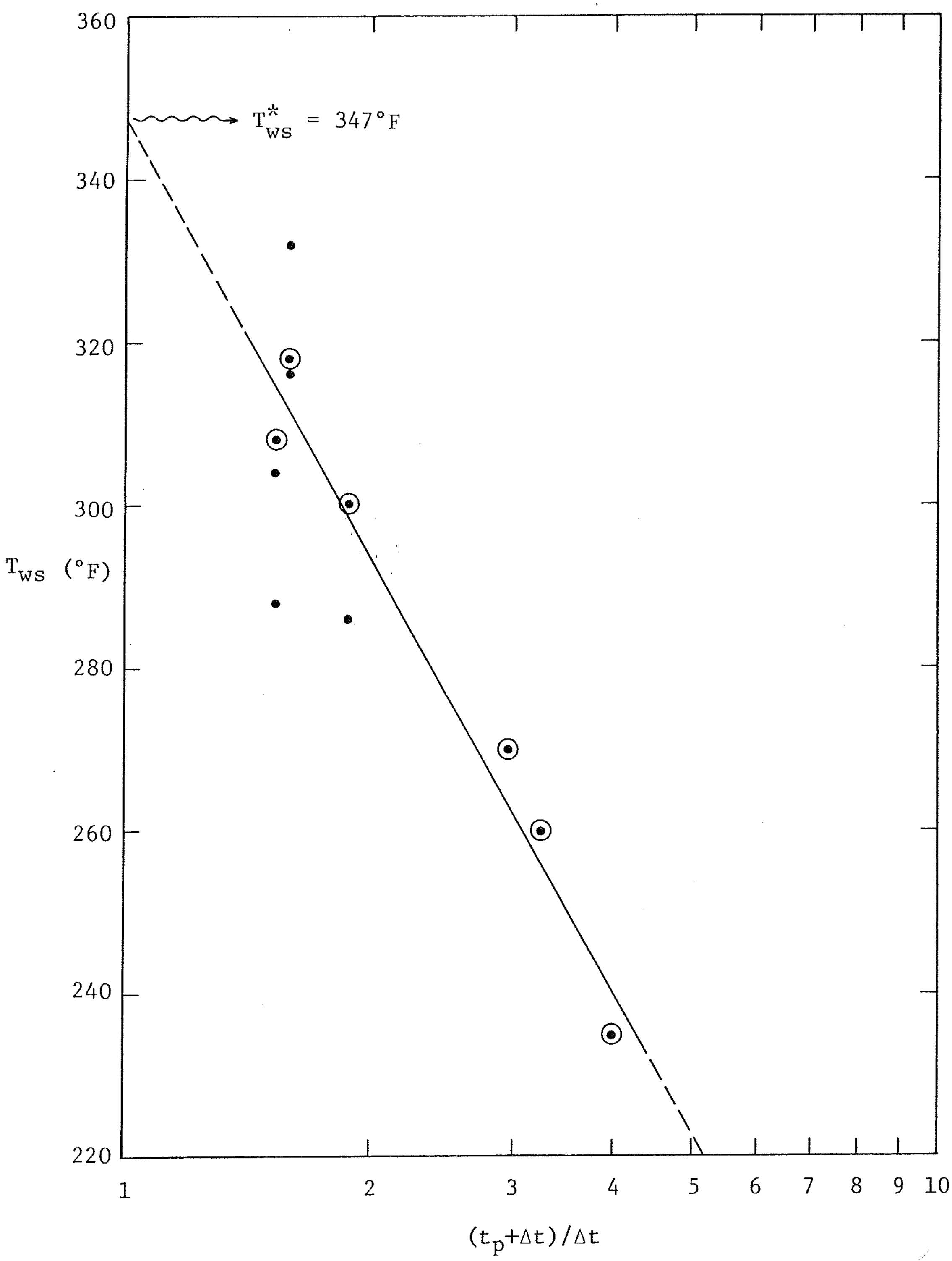

FIGURE F-2. Ore-Ida No. 1 Temperature Build-Up Plot
Depth: 7,960 Feet

TABLE F-4

EQUILIBRIUM TEMPERATURE CALCULATION

Depth = 7,960 feet

Depth reached at 2030 hours on 9/29/79

Circulation stopped at 1930 hours on 9/30/79

Total circulation time (t_p) = 23.0 hours

Temperature buildup data:

Log Type	Date Run	Δt (hrs)	$(t_p + \Delta t)/\Delta t$		T_{ws} (°F)
1. Dual Induction Guard Log	10/1	7.75	3.97		235
2. Fracture Finder-Microseismogram	10/1	10.25	3.24		260
3. Compensated Acoustic Log	10/1	11.75	2.96		270
4. Temperatrue Log, Run #5	10/1	26.25	1.88	*267	300, 286
5. Temperature Log, Run #6	10/2	39.25	1.59	*270	316, 318, 332
6. Temperature Log, Run #7	10/2	44.25	1.52	*283	304, 288, 308

Fig F-2 circled values

* = Max BHT off of Temperature logs all other values are max recording thermometers listed in "remarks section" on temp. logs

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where K = thermal conductivity of the formation,

c_p = specific heat of the formation,

ρ = bulk density of the formation,

r_w = wellbore radius, and

t = circulation time.

Many of these parameters are unknown for Ore-Ida No. 1. However, for most geothermal wells the value of ($Kc_p \rho r_w^2$) is about 0.4 per hour. Assuming this value, the t_{pD} for this case is

$$t_{tp} = 0.4t$$

$$= 9.2$$

From Figure F-1 it is seen that for t_{pD} = 9.2, the modified Horner plot shows a strong curvature, which is not seen in Figure F-2. This may imply that the conventional Horner technique may be adequate for this case. However, the true curvature may be masked by the data scatter or the value of t_p or ($Kt_p/c_p \rho r_w^2$) may be much higher, in which case the modified Horner plot may be almost linear. This problem has not been resolved.

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APPENDIX G

GEOTHERMAL WELL DRILLING PLAN

for

ORE-IDA No. 1,

ONTARIO, OREGON

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June 1979

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GEOTHERMAL WELL-DRILLING PLAN FOR ORE-IDA NO. 1, ONTARIO, OREGON

Site Preparation

The drilling will take place at the Ore-Ida Foods, Inc. plant, in the NE 1/4, S. 3, T. 18 S., R. 47 E., W.M., on a drill pad triangular in shape with sides of 260 feet, 230 feet and 300 feet (maps, figures G-1, G-2). Ore-Ida Foods with CH2M and local contractors will provide necessary site preparation as follows:

1. Level and compact, where necessary, the drill pad (level to 1"/100').
2. Excavate the mud reserve pit (sump) and stabilize slopes.
3. Construct a cellar 8 x 8 x10± feet (figure G-3).
4. Drill, run and cement a 20-inch conductor pipe to 40 feet or a landing below gravels.
5. Drill rat and mouse holes.
6. Bridge and/or fill any culverts and drains within sites.
7. Remove and reroute utility lines and above-ground pipes in the site.

Site Cleanup and Restoration

When the drilling is complete and testing requiring use of the rig is complete, the contractor will remove the drill rig and all rig-associated materials. Ore-Ida Foods will dispose of drilling fluids, backfill mud sump, and dress and restore the pad. The site will be prepared to meet the needs of future testing and logging, or production.

Drilling Water

Ore-Ida will provide drilling water, through a 2-inch pipe line.

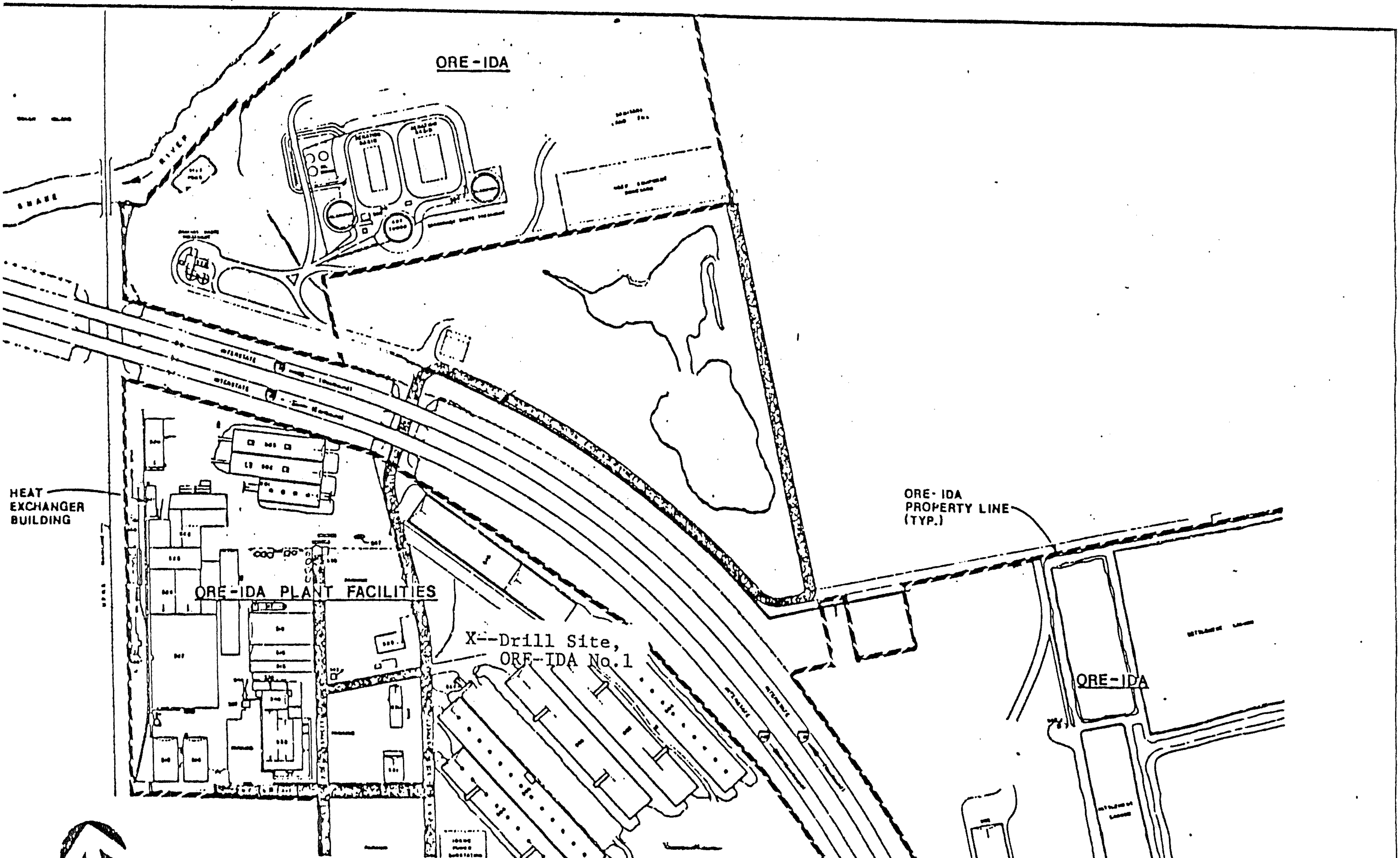

FIGURE G-1

ORE-IDA FACILITIES SITE PLAN

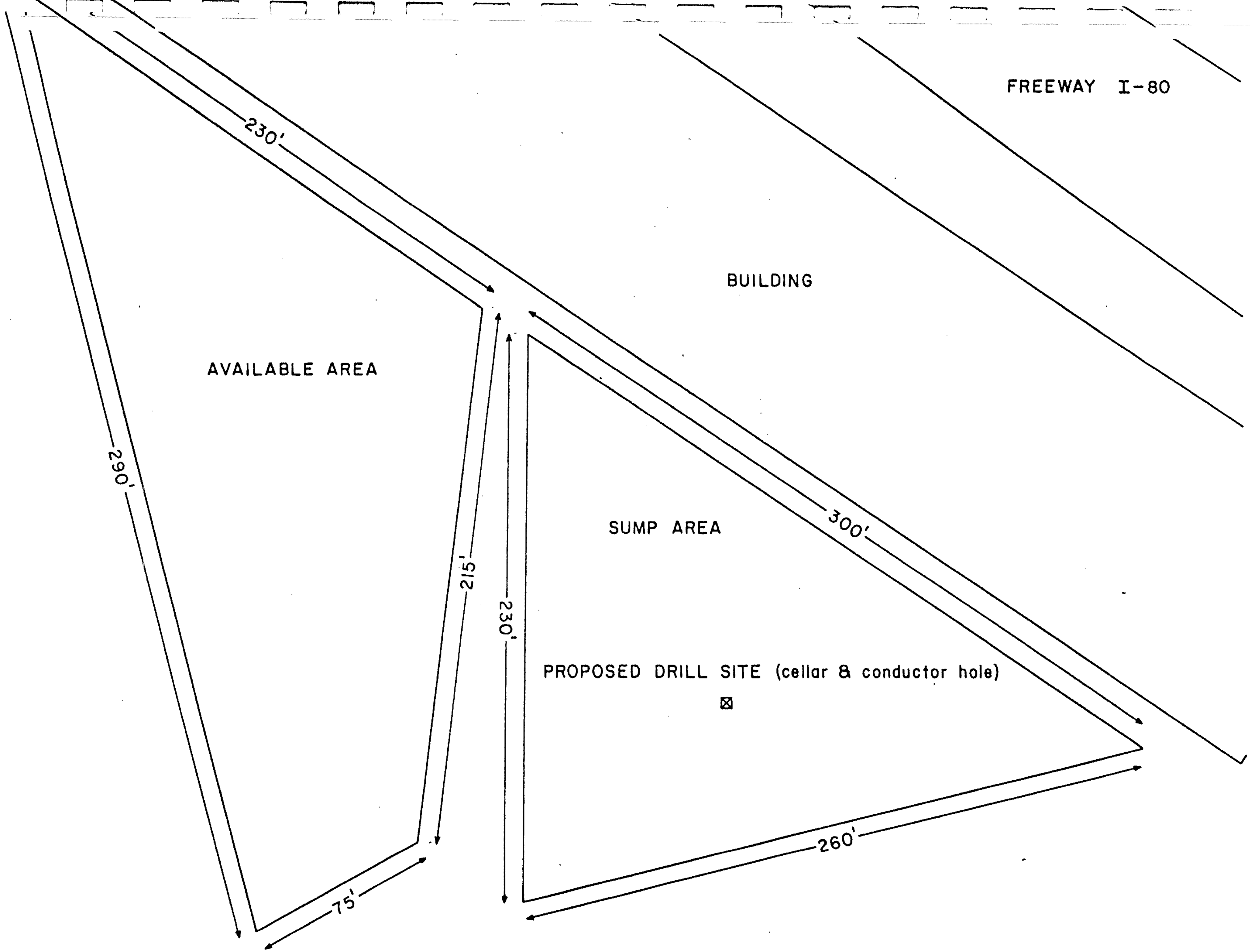

FIGURE G-2. Dimensions of proposed drill site

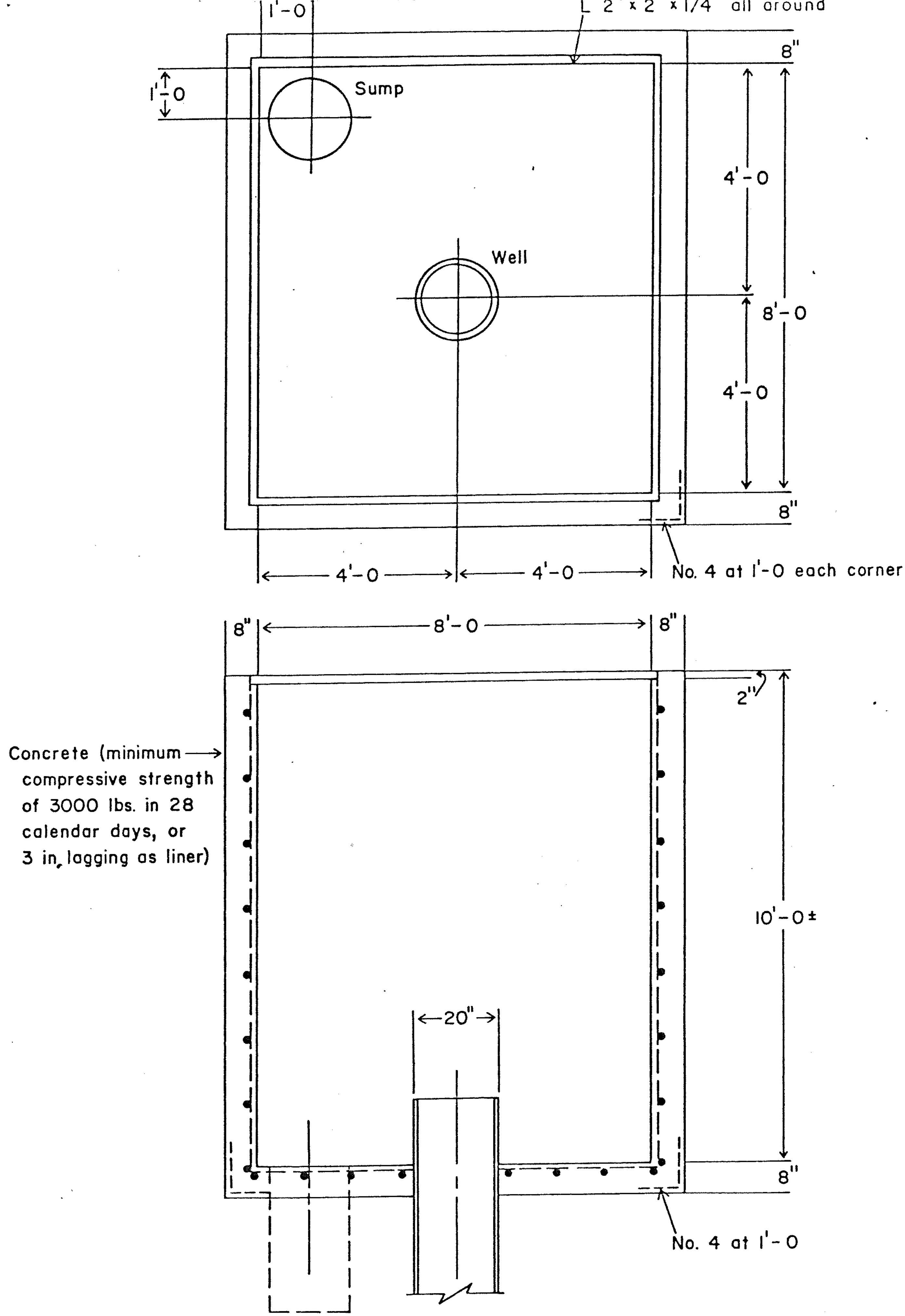

FIGURE G-3. (Concrete) Cellar construction detail

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Electric Power

Driller will provide own power from rig generators, but may obtain incidental power from lines to plant power sources.

General Operational and Logistics Support

Ore-Ida will provide access to the site area, storage areas for mud and cement and loading dock facilities.

Drilling Operations

The site will be prepared as described in prior paragraphs before moving in the drill rig, except that the conductor hole may await arrival of the rig if a local contractor is not available to do the work in adequate time. The drilling rig will be set on the drill site and centered over the conductor pipe prior to spudding. All drill pipe and drill collars will be visually inspected on location before they are used in the drilling operation. No drill pipe that does not meet API Grade No. E will be used in the drilling operation. Drill collars will be magnafluxed at Ore-Ida's expense.

Formations

Drilling operations are likely to encounter the following formations at the indicated depths:

Formation	Depth
Idaho Group silts, clays, sands basalt flows and tuffs	50 to 6,000± feet
Basalt flows	6,000± feet to 8,000± feet

Surface Hole

A 17½-inch hole will be drilled to between 700 and 1,000 feet depth or to the first competent formation near that depth using conventional drilling methods. The minimum requirements are:

a. 6 drill collars, 18,000 lb.

b. Two pumps, one 750 HP input pump and one 500 HP input pump.

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c. Rotary table sized at 20½ inches to pass 17½-inch bits.

d. Casing load 38,000 lb. This hole will be drilled with clay base and gel to ensure enough viscosity to clean the hole during drilling. Upon completion of the drilling, 13-3/8-inch surface casing will be run to TD and cemented to surface through the casing in a continuous operation. The 13-3/8-inch casing is designed as follows: 54.5 lb, K-55 buttress.

Main Hole

A 12¼-inch hole will be drilled below the 13-3/8-inch casing shoe to a depth between 6,500± and 8,000± feet. The minimum requirements are:

a. 20 drill collars, 60,000 lb.

b. Two pumps with minimum combined output of 550 gpm, at 1,500 psi.

c. Casing load, 348,000 lb.

The 12¼-inch hole will be drilled with a low-solids, non-dispersed, gel, chemical mud system. Circulation will be maintained with use of lost circulation materials and/or cementing off lost circulation zones if required. If hole conditions indicate that drilling with water would be more suitable than mud, water will be used as the drilling fluid. If hole conditions indicate usefulness, 9-5/8-inch casing will be run and cemented to surface in a single stage. If circulation loss will not allow a single-stage cement job, a DV tool will be considered for a two-stage cement job.

The 9-5/8-inch casing is designed to include thermal stresses for a temperature change of 275°F.

Drilling may continue below the casing or liner with 8-3/4-inch bits, to a depth between 6,500± and 8,000± feet. Zones of interest will be tested as described in subsequent paragraphs.

Well Equipment

The following equipment will be used as noted:

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a. Twenty-inch conductor pipe will be furnished by the operator, set with a conventional water-well drilling rig or the contracted main drilling rig and cemented with ready-mix cement. This may be prior to or after moving in the drilling rig.

b. Thirteen and three-eighths-inch casing will be furnished by the operator and set to 700±feet , in a 17½-inch hole (figure G-4).

c. Nine and five-eighths-inch casing will be furnished by the operator and set to between 6,500± and 8,000± feet, in a 12¼-inch hole (figure G-4).

d. Figures G-5, G-6 and G-7 are schematic diagrams of the wellhead equipment to be installed upon completion of a geothermal resource well. Installation will be supervised by the project drilling engineer with assistance from WKM engineer. The 12-inch by 10-inch WKM expansion spool will tie the 13-3/8-inch surface casing to the 9-5/8-inch casing as shown in the diagrams.

Equipment and Services

Blowout Preventor and Control Manifold

Series 900 WKM geothermal wellhead, 12-inch Series 900 Schaffer dual hydraulic control gate and Hydril GK will be installed. Flow spool with drilling spool, master valve and expansion spool will be included. Outlets from the BOP stack will be double-valved at the stack and at the control manifold. All valves will be 2-inch full-opening or larger, 3,000 psig working pressure. The choke manifold will consist of 2-inch single-valved outlets on each side of a cross, with two adjustable chokes for control (figures G-5, G-6 and G-7).

Float and Guide Equipment

The 13-3/8-inch casing will use conventional guide shoe with insert fillup, and top plug.

Float equipment for the 9-5/8-inch casing and/or 5½"liner will be conventional and furnished by the industry suppliers to consist of a guide shoe and cement collar.

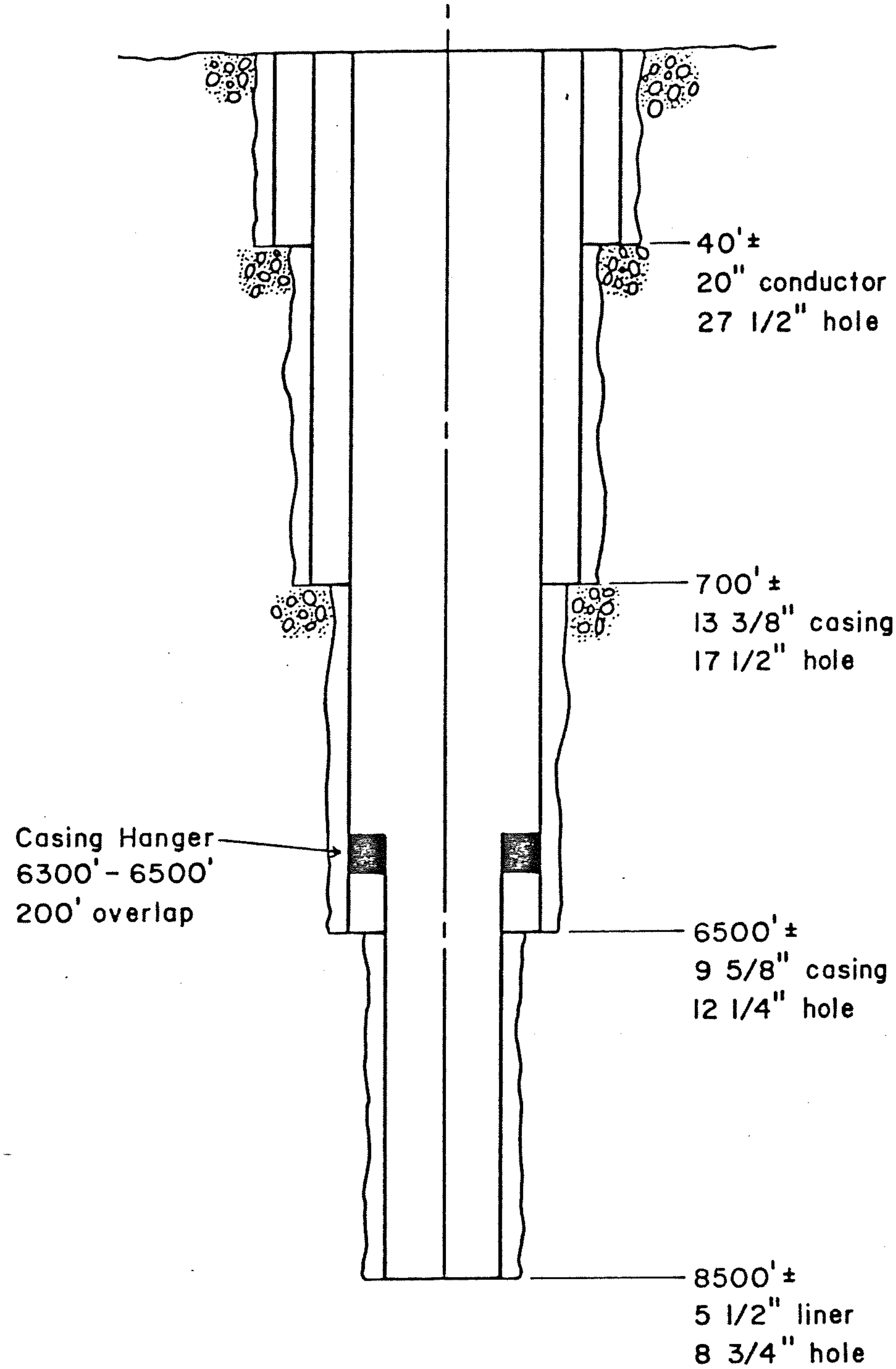


FIGURE G-4. Well casing design

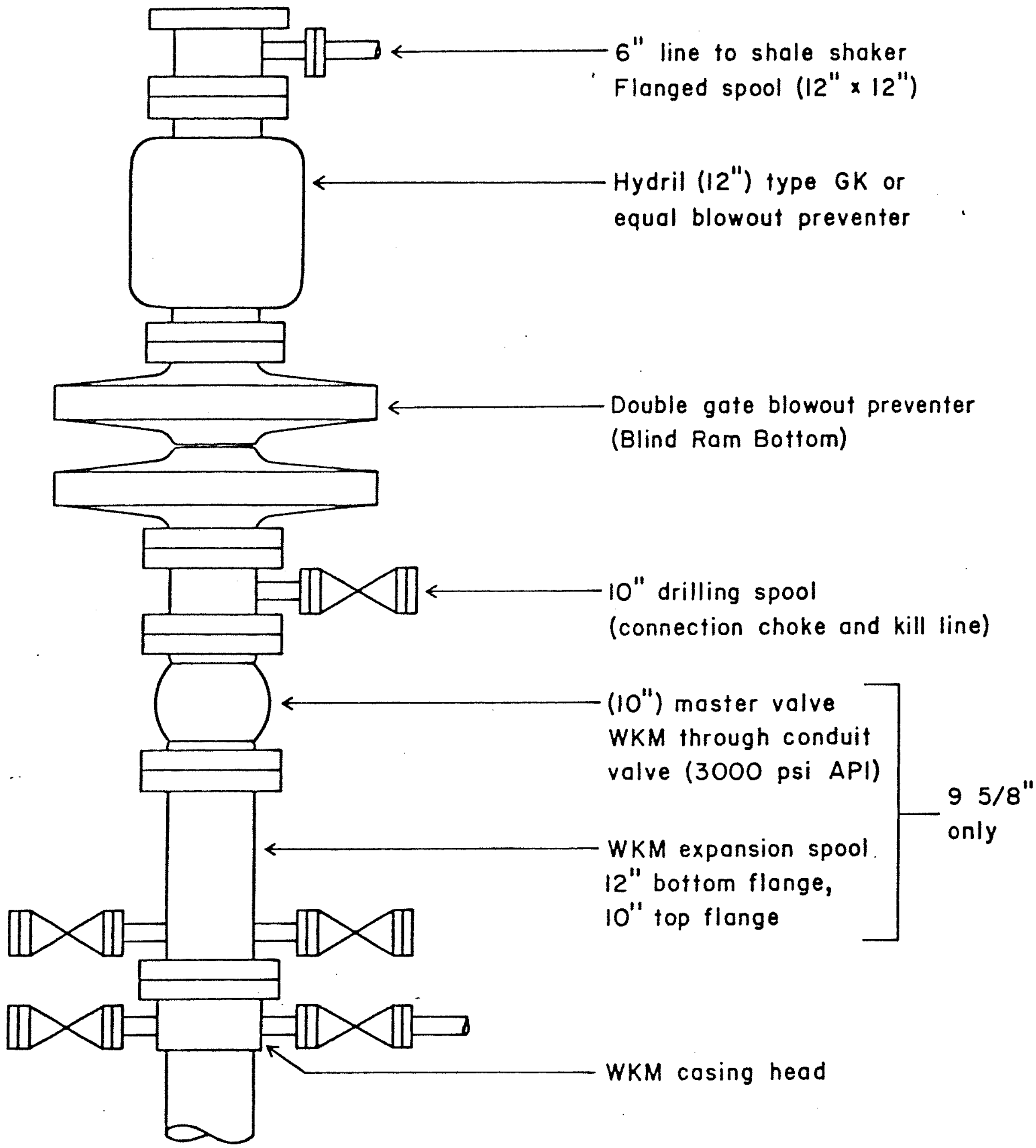
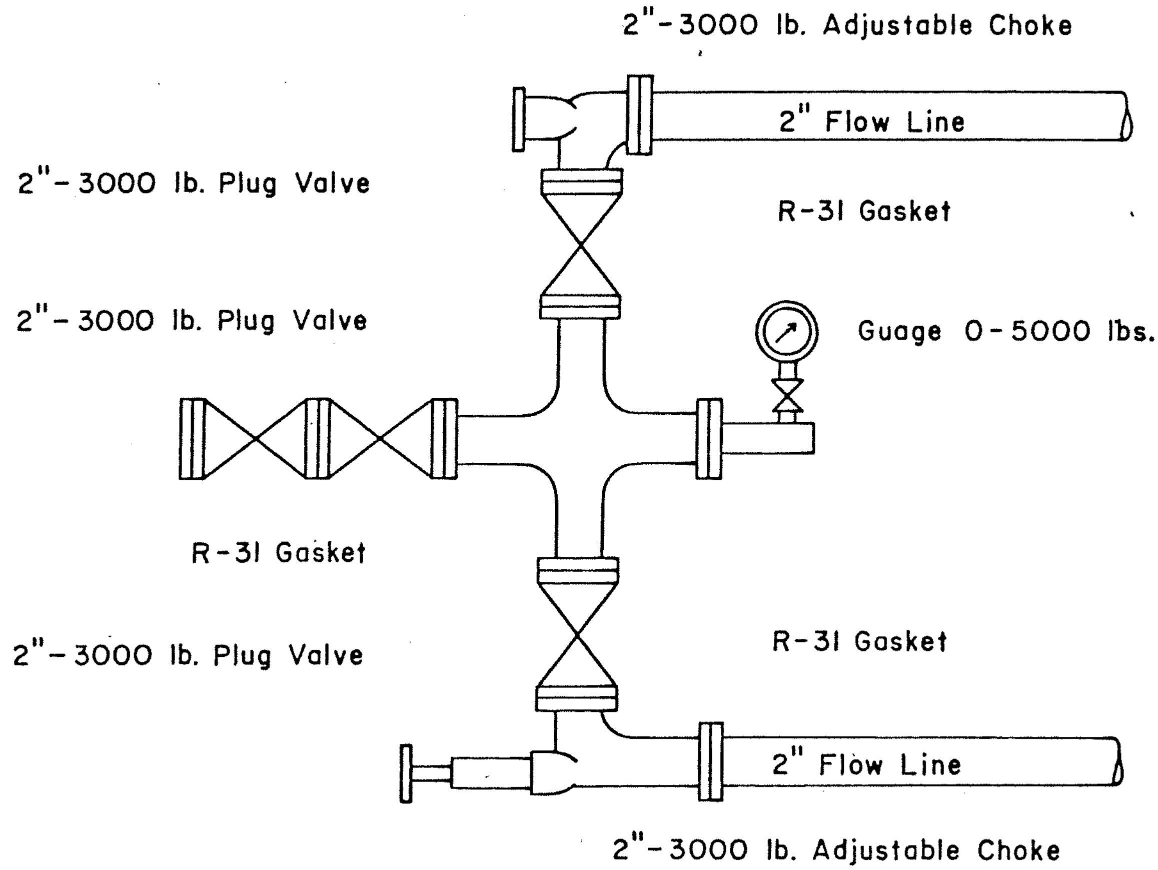


FIGURE G-5. BOP for drilling below 13 3/8" and 9 5/8" casing shoe



13 sets of 2"-900 lb. Flange Bolts and Nuts
2 sets of 2"-1500 lb. Flange Bolts and Nuts
4 R-57 Ring Gaskets
13 R-31 Ring Gaskets
2 R-24 Ring Gaskets
3 2"-3000 lb. x 2" Threaded Flanges
1 2" Hi-Pressure Bull Plug W/1/2" Side Opening
1 5000 lb. Guage
1 2"-3000 lb. Ball Choke
1 1/2" Needle Valve

FIGURE G-6. Choke manifold assembly

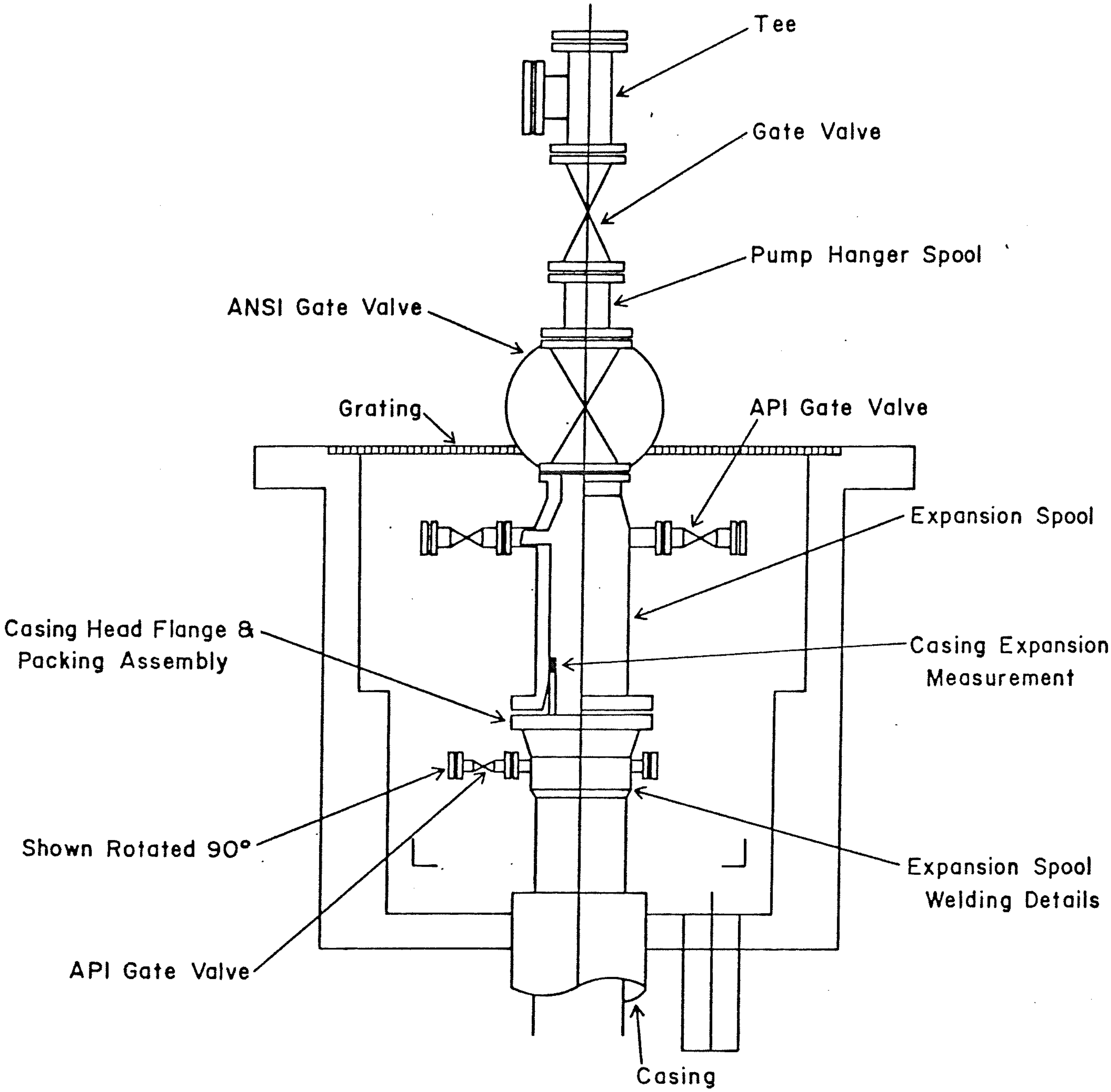


FIGURE G-7. Schematic diagram of wellhead equipment to be installed on completed well

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Centralizers

Centralizers for the 13-3/8-inch casing will be bow-spring placed 15, 40 and 120 feet above the shoe.

Support Services

Down-Hole Equipment

The following sizes will be needed for this test hole: 17½", 12¼" and 8 3/4" standard bits, conventional to the drilling industry, will be used. These bits will be provided by the supply companies that service the drilling industry.

It may be necessary to incorporate reamers and stabilizers in the drill string near the bit to maintain proper hole size and to control deviation. The drilling supervisor will determine the selection of the tools to be used and their placement in the drill string. These may include drillable wing stabilizers for the 12¼-inch hole.

Tools and services for any drill-stem testing will be provided by service companies.

Drilling Fluids

The drilling fluid used for the surface hole for depths from 40± feet to 700± feet will consist of gel water and clay base. This will provide viscosity to carry drill cuttings and suspend solids when not circulating.

The drilling fluid to be used for the main hole at depths of from 700± feet to 8,000± feet will be a low-solids, non-dispersed system using lignosulfonate. Additional materials for flocculating drilling solids may be used. A fluid mix will be engineered to provide good drill-solids carrying capacity while having fluid properties that allow maximum rates of penetration.

Water <u>may</u> be used for drilling the hole at depths below the 13-3/8-inch casing. The hole may be drilled with water circulated through the reserve pit if the hole will clearly stand up and if

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ambient temperatures permit. Corrosion inhibitors and high-viscosity sweeps would be used as necessary for tool protection and hole cleaning. Conventional mud programs with weights and wall cake designed to avoid hole troubles will be used as necessary to drill the entire hole. The mud should handle temperatures up to 300°F without special additives. Above 300°F, a mud using a surfactant with lignite should be stable up to about 450°F.

Mud Logger and Dectection Equipment

A mud logging unit will be used from depth of shoe of 13-3/8-inch casing to total depth. The mud logger will prepare four (4) sets of samples, washed and dried along with a sample description log and other contracted services. Additional sample sets may be required. The unit will include a chromatograph option.

At a depth of between 700± and 1,000± feet, the mud logger will install H_2S detectors in the flow line and under the floor, along with H_2S alarm system. The detectors should have a sensitivity in the range of 0 to 20 parts per million, with alarm setting at 5 parts per million to provide safety for personnel working at the drill site.

Mud pit-level change detectors will also be used after the 13-3/8-inch casing is set, connected to recorders in the mud log trailer and readout gauges at the driller's console.

Cement and Cementing Services

The following cement program has been designed for conventional requirements of a geothermal wall. Conditions and special circumstances determined during logging may require alternate programs.

Prior to cementing a string of casing at any of the designated intervals, cement tests should be run with the cements to be used and the waters with which they will be mixed.

In the event that during the cementing program operation the cementing design requirements have not been met, alternative cementing procedures will be required. If inadequate fill-up occurs and the top of the cement is near surface, remedial cementing through the casing head and down the annulus should be considered. If fill-up and formations prohibit a "top job," then squeeze cementing in the 13-3/8-inch

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casing strings should be considered through perforations below a sliding-sleeve, drillable cement retainer.

Casing and Cementing Program

Casing Equipment and Method

Run guide shoe with insert fill-up. Tack weld and Bakerlok bottom 4 collars, weld shoe solid. Use top rubber plug only, plug holding head. Bump shoe on plug. Place centralizers 15, 50 and 120 feet above shoe.

Cement Slurry

Use 100% excess slurry volume mixed Class G cement premixed 1:1 perlite, 2% gel and 40% silica flour. Use cement accelerator based on bottom hole temperature.

The materials and procedures are the same in case a 9-5/8-inch casing is run. Pressure tests to 1,500 psi will be required.

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SUMMARY

Size Hole	Size Csg.	Setting Depth	Cementing	Remarks
27½ in.	20 in.	40± ft	Ready Mix	Set with dry digger hole
17½ in.	13-3/8 in.	700± ft	Cmt to surface	
12¼ in.	9-5/8 in.	6,500± to 8,500± ft	TDB	
8-3/4 in.	----------	6,500± to 8,500± ft	---------	

Mud Program

Interval	Type	Weight	Viscosity	Fluid Loss
40-1,000± ft	Gel Lime	8.5/.7	50/60	NC
1,000± to TD ft	LSND	8.5/8.7	35/50	6-10 cc/30 min.
Optional 1,000±-7,500± ft	Water	8.3	28	NC
7,500±ft	LSND	9.0 or less	34/40	20 cc or less

NOTES:

1. In the event circulation is lost in the hole between 1,000± and 7,500 ft, lost-circulation material should be used for control. If lost-circulation material does not adequately control the loss, the hole should be cemented in the LC zone.

2. High viscosity sweeps should be conducted prior to running the 13-3/8 and 9-5/8 in. casing strings.

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Hydraulics

Hydraulics will be required as shown:

Hole Size	Pump No.	(GPM) Output	AV-DP	AV-DC	Viscosity	Density	PV	YP
17½ in.	1 & 2	1,200	105	143	32/34	8.5/8.7	8	12
12¼ in.	1	600	118	213	Water			
8-3/4 in.	1	330	144	216	Water *35/40	9.0 or less	10/ 12	3/6

* Alternate

Samples and Deviation Surveys

The well site geologist may alter the sample interval, but the present plan is to sample as shown:

Interval	ft/Sample	Survey Interval	Maximum Deviation	Max. Deviation Between Survey
0- 1,000±ft	30 ft	100 ft	2°	2°
1,000± to 7,500±ft	10 ft	200 ft	5°	2°

The depth and frequency of the surveys will be as indicated or as specified by well-site supervisor. Two survey instruments will be on hand at all times, and they will be alternated when obtaining surveys. A monel collar and directional instrument may be required to run directional survey after reading on T.D. at Ore-Ida's cost.

Stabilization

The stabilization procedure is outlined below:

1. 17½-in. hole: below conductor run 60,000 lb of 7" and 6" DC with NRS on top of first.

2. 12¼ in. hole: bit, 3 pt, drillable wing stabilizers every 90', bumper sub on top DCs. Adjust as necessary for angle control.

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3. Barefoot 8 3/4" hole: as 2 above.

Coring, Logging and Testing

The following logs will be run in the 17½" hole before casing is run and in the lower hole at 6,200± feet and below at the direction of the well-site geologist.

Type	Logger
Caliper	Commercial
Compensated Density w/Caliper	Commercial
Compensated Neutron w/GR	Commercial
Focused DIL	Commercial
BHC Acoustic Log	Commercial
Temperature Log	Commercial
Sonic Log	Commercial
Magnetic Log	Commercial

When the above logs are run on the intermediate and main holes, the logs should be taped. A computerized evaluation (synergenic evaluation) will be prepared from the taped log data.

Testing Program

The drill-stem tests will utilize conventional test equipment; the test procedure is as follows:

Initial Flow Period	As ordered
Initial Shut-In Period	As ordered
Final Flow Period	As ordered
Final Shut-In Period	As ordered.

Samples and Analysis. All fluid samples will be available to the USGS and the DOE for their independent analysis. Pressure-versus-time and temperature-versus-time charts will be recorded during the test procedure, to aid in the evaluation of each resource-interval test.

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Rig Requirements and Specifications

Hoisting Requirements. The derrick substructure and draw works will require a minimum of 300,000 lb hoist capacity.

The maximum hoisting operation will be running a 9-5/8 in. casing at 8,500'. Substructure clearance will be adequate to accept BOP stack (figures G-5 and G-7).

High-Pressure Pumps. Minimum requirements are one 750-horsepower pump and one 500-horsepower pump. It may be necessary to utilize both pumps on the 17½" hole. The 12¼" and 8-3/4" holes will require one pump, and will need one pump for standby purposes.

Low-Pressure Pumps and Circulating System. Minimum requirements are two centrifugal pumps. Two pumps will be necessary to allow drilling-fluid additives to be properly mixed and to operate drill-solids removal equipment.

Surface Support Equipment. A desander capable of handling a minimum of 300 gpm will be required, as will a high-speed, double-screen shaker. The surface pits will be properly designed, to allow compartmental bypassing. They will have a volume of 1,000 bbls.

Drill Pipe and Drill Collars. For all drilling operations from the surface to the setting of the liner, the drilling contractor will provide 70,000 lb of drill-collar weight in air whose minimum OD will be 7 in. All drill collars will have the same connection and will be inspected on location prior to being picked up and run in the hole at Ore-Ida's expense. For drilling below the 9-5/8 in. casing, the drilling contractor will provide 70,000 lb of 7" OD drill-collar weight in air.

The drilling contractor will provide 5 in., 19.5#/ft drill pipe for this operation. All drill pipe will be inspected on location prior to being pickedup and run in the hole at Ore-Ida's expense. Minimum specifications acceptable will be grade E. Inspection will include both tube and end areas. Hard banding will be smooth and contoured. Tensile strength will be such that 100,000 lb of pull will be left in the drill pipe string under any normal operation. Collapse strength will be that required for well killing, squeeze cementing or any other operation.

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Traveling and Auxiliary Equipment. The contractor will check the crown block, traveling blocks, draw-works brakes, auxiliary brakes, swivel, hook, kelly, kelly cock, and handling tools for wear and capacity before the equipment is put to use at Ore-Ida's expense. Elevators, spiders, slips, bails, and handling tools are to be magnafluxed at Ore-Ida's expense before they are used. Minimum rating of all traveling equipment and crown block will be 400,000 lb.

At 700± ft the operator will provide 3,000 psig working-pressure expansion spool. Ore-Ida will provide a 12', 3,000 psig working-pressure double gate, a 12-in. double-outlet drilling spool, and a 12-in., 3,000 psig working-pressure spherical annular preventor. The operator may provide a 12-in., 1,500 psig working-pressure rotating head above this spherical preventor. Figure G-5 is a schematic diagram of this control equipment.

This control equipment should be rated to handle pressure as indicated, temperatures to 175°C and sour and corrosive fluids.

A 4-in. geothermal flowline will be installed on one outlet of the drilling spool for geothermal testing. This equipment will be provided by the operator.

Instrumentation and Auxiliary Equipment. The following recording instruments are to be furnished by the drilling contractor:

1. A weight indicator at the driller's console and on the dead line.

2. An independent piano wire-line unit with sufficient wire line for operation to total depth.

3. Accumulator unit to operate BOPs 1½ cycles, with a remote-control station on the drilling floor.

4. A standard degree deviation instrument.

Rig Inspection. Two inspections will be conducted. The first inspection will be conducted prior to bid award, by the drilling supervisor's representative, to verify that the rig meets bid specifications and a 2d when the rig is over the hole and ready for operation. The drilling supervisor will verify that the same equipment originally inspected has been mobilized. Other, periodic safety inspections will also be conducted.

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APPENDIX H

DATA ANALYSIS AND DRILLING SITE SELECTION

for

ORE-IDA PROPERTY

ONTARIO, OREGON

including

geological, geophysical and hydrochemical

factors

Plates I-VII were not reproduced for this appendix.

Murray C. Gardner
James B. Koenig

Geothermex, Incorporated

October 1978

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CONCLUSIONS

1. The seismic and hydrogeochemical studies conducted for phase 1 of the Field Experiment have encouraged the decision to proceed to the drilling phase. No negative factors evolved from the studies and data analysis.

2. Additional subsurface geological data from deep drill holes near Ontario, in both the Snake River depression and the adjacent borderland, confirm that rocks of the Idaho Group, an insulator, occur to a depth in excess of 1.5 km (5,000 feet). The Ontario area probably is located on an intradepression graben, within which the Idaho Group rocks may be as much as 1.9 km (6,200 feet) thick.

3. The Columbia River Group basalt flows, with interbedded sands and tuffs, underlie the Idaho Group. The basalts are about 1 km (3,300 feet) thick and are fractured in zones of tectonic stress, such as along the boundary of the Snake River depression. Permeability afforded by interflow scoria, volcanic rubble and vertical cooling joints will be interconnected further and enhanced by high-angle fractures.

4. A seismic reflection survey at Ontario identified a reflector horizon at a depth of 1.9 km (6,200 feet), which serves as an effective seismic basement. Its rough surface suggests fault displacement and/or topographic relief from erosion. Velocity characteristics of the reflector suggest it is basalt.

5. Data from the seismic survey are interpreted to suggest throughgoing west-northwest-striking faults with minor displacement in the Idaho Group, probably extending into the underlying Columbia River basalts. The faults have been projected geometrically to the depth where temperatures greater than 150°C are forecast, below 2.2 km (7,000 feet).

6. Gravity surveys suggest northwest-trending structures in the Ontario area but cannot be used to locate specific faults.

7. An aeromagnetic survey indicates structures of northerly and northwesterly trends in the vicinity of Ontario; however, these could not be identified on the basis of known geology nor were magnetic gradients coincident with faults indicated by the seismic survey.

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8. Hydrochemistry of a limited number of water wells in the Ontario area suggests some leakage from a deep-seated aquifer. Total dissolved solids, chloride and sulfate concentrations are unusually high for waters of the area. Some of these high concentrations are in wells close to the faults indicated by the seismic survey.

9. The general northwest trend of heat-flow anomalies in the Snake River depression and bordering structural elements support the indications that northwesterly faults occur at Ontario. However, Ontario is not associated with any of the narrow zones of high heat flow that appear to represent major faults.

10. It is possible to select a primary and a secondary site for drilling the initial exploratory production holes, based on the above, and especially on the evidence of one near-certain and one possible fault zone illuminated by the seismic survey.

11. The primary site is located at the southeast of Ontario. It is within an area limited by the freeway (I-80 N) to the east-southeast, the Treasure Valley Community College to the west-southwest, 9th Avenue on the south and 7th Avenue on the north. It would be about 1.7 km (1.1 miles) from the Ore-Ida plant and the planned heat-exchanger facilities.

12. The secondary site is located at the northeast of Ontario. It is on the Ore-Ida property, between the freeway and the Snake River. It is adjacent to the settlement lagoons, about where the Field Experiment Proposal initially recommended that drilling sites be selected.

13. The primary site is chosen to take advantage of the projection at depth of the near-certain fault and therefore is more favorable technically, as this enhances the probability of drilling into rocks with high permeability in the potential thermal zone. The fault would possibly provide a channel along which temperature isotherms would be raised surfaceward. These two factors might permit a shallower hole with a shorter length of completion zone necessary to produce thermal fluid.

14. The primary site should be drilled to make the all-important first test of the resource. The secondary site could then be drilled to delineate field extent and/or for reinjection objectives. Should the secondary site prove to contain sufficient producible fluid at temperatures above 150°C, the roles of the two holes could be switched, so that a less expensive pipe can be constructed to carry waste fluids to a southern reinjection site.

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RECOMMENDATIONS

1. Do no further geological, geophysical and/or geochemical surveys. This includes temperature-gradient and seismic surveys.

2. Investigate rights of way from the primary site to the Ore-Ida property for movement of fluids to heat exchangers and waste disposal areas.

3. Procure land positions at the primary site by purchase, option to purchase and/or lease. Be certain that these carry all subsurface mineral and water rights, including disposal rights, plus full rights to surface occupancy and land use.

4. Determine availability of temporary disposal sites for geothermal wastes for period of reservoir testing (before disposal well is completed).

5. Proceed to the well-design phase of the Field Experiment.

6. Prepare specifications for all drilling, completion and testing operations for the primary site and, with necessary modifications, for the secondary site.

7. Solicit bids from selected drilling contractors to drill the first hole at the primary site.

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INTRODUCTION

Preface

Phase I of the Field Experiment, Food Processing Industry, Geothermal Energy, by Ore-Ida, under contract No. ET-78-C-07-1725 with DOE, provides that a seismic survey, data analysis and decision where to drill the first well will be accomplished and reported. GeothermEx, Inc., by letter contract from CH2M-Hill, was appointed sub-subcontractor to perform data analysis and reporting tasks for phase 1.

The seismic survey was planned during May and June of 1978 and a sub-subcontract was signed between CH2M-Hill and Geotechniques, Inc. (GTI), Boise, Idaho, on 29 June 1978. Geotechniques agreed to provide the qualified team and equipment to collect the field data, process the data and report to GeothermEx and CH2M-Hill the results of the seismic survey. The GTI report is a separate appendix to this data analysis. The information and interpretations from the GTI report have been used for GeothermEx's applications to site selection. Additionally, GeothermEx used the services of an associated seismologist, independent of GTI, to evaluate the field procedures of GTI, the field data records, the data printout sections from the data analytical laboratory, and the interpretations of GTI. GeothermEx's seismologist independently interpreted the data laboratory's sections and drew interpretive maps.

GeothermEx solicitied additional geophysical data from other sources. Dr. Couch, Geophysics Group, Oregon State University, was contracted to provide a Total Field Magnetic Anomaly Map of the vicinity of Ontario, Oregon, from data obtained during 1976 for other programs, but not previously processed and contoured. The result was a map, scale 1:62,500, with contour interval of 10 gammas, extending for a minimum radius of 3.5 miles from Ontario.

Private sources provided additional gravity maps of the Ontario area. These are residual gravity contour maps, scale 1:48,000, with contour interval of 0.5 milligals. In addition, the public Bouguer gravity maps of southwestern Idaho and eastern Oregon, scales 1:500,000 and 1:250,000, respectively, were synthesized into a single map, scale 1:250,000, to include the Ontario area. Previously, the Ontario area was at the margins of both maps. A gravity map of Weiser, Idaho, scale 1:125,000, was also studied.

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GeothermEx sent a field geochemist to Ontario to canvass the availability of wells for water sampling. Very few wells were available and most of these were shallow. Thirteen samples were collected from wells and springs that included those available in and near Ontario and a few at Weiser, Idaho. These samples were analyzed by a commercial laboratory, and the results are discussed herein.

The surface and subsurface geology of the Ontario area were described by the Technical Proposal, Volume 1, in response to PON EG-77-N-03-1553. For the data analysis, additional information was developed by acquiring access to new and private public lithologic and electric logs from deep drill holes. This information has been used to clarify the description in the Technical Proposal and to construct geologic cross sections in the form of fence diagrams.

Compilations of these data and synthesis of the interpretations have led to redefinition of the potential resource and location of an optimum drilling site and recommendation of actions toward obtaining land position and permits to drill.

Scope and Purpose of Report

This report is submitted as a concise presentation of the facts and interpretations developed by the activities described in the Preface. The report has as its objective providing the prime contractor, subcontractor and DOE with documentation of the results of the data analysis. With these results and interpretations, DOE and the prime contractor are to reach mutual agreement on whether to proceed to the drilling phases and at what location the initial well should be drilled.

DATA ANALYSIS

Drill Hole Stratigraphy and Structure

The original *Description of the Resource* from the Technical Proposal, Volume I, has been modified and supplemented by information obtained during the past few months. Therefore, it is resubmitted herein as the vehicle for reporting the new data and interpretations.

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The Snake River geomorphic province is a topographic and structural depression in the crust that extends from about 32 km (20 miles) northwest of Ontario in east-central Oregon, eastward across Idaho to Yellowstone Park in Wyoming. The western part of the depression is referred to as the Snake River Basin. The boundary of the depression eastward, northward and westward of Ontario is shown on the accompanying Generalized Geologic Map (plate I). Lithologic and electrical logs from drill holes on different sides of the boundary of the depression make it clear that a significant structural discontinuity occurs at its margin. There appear to be about 1.8 km (6,000 feet) of relief on the top of the Miocene Columbia River Group between Weiser and Ontario.

The Snake River Plain formed as a crustal rift or compound graben beginning in late Oligocene or Miocene time; crustal extension continued episodically at least into the Pleistocene epoch. Volcanism has taken place almost continuously during that time, within the plain and at the margins of the uplands to the northwest and south.

Regional seismic surveys indicate that compared to the thin-crusted Basin and Range province, the Snake River Plain exhibits a totally thicker crust. However, the upper or granitic layer appears to be absent or quite thin and patchy beneath the plain. The crust in the region therefore consists of a thin, hot intermediate layer on top of a thick, hot lower crust. We may infer that the granitic layer has been altered, remelted, or is absent because of rifting and has been replaced by upward-moving mantle differentiate. This is typical of flood basalt and crustal rift areas. This provides the model for a region of significantly higher heat flow than normal and the support for presence of hot water systems.

Thousands of meters (thousands of feet) of fluviatile and lacustrine sediments and volcanic rocks have been deposited in the depression during Holocene to Miocene time. There are more than 4 km (12,500 feet) of Tertiary and Quaternary bedded sedimentary and volcanic rocks in the deeper parts of the basin and at least 2.5 km (8,000 feet) of these rocks in the basin near Ontario. These rocks decrease in thickness to the northeast, west and northwest of Ontario. Composition of the Tertiary and Quaternary bedded rocks ranges upward in Chevron Highland No. 1, S. 24, T. 6 N., R. 5 W., from rhyolites and andesites to andesitic tuffs, basalts, basaltic to rhyolitic tuffs, sandy and silty tuffs, sandstones, siltstones, claystones, clays, silts and gravels. The Highland No. 1 drill hole is 3.8 km (12,000 feet) deep and represents one of the thickest Tertiary and Quaternary sections in the depression. In the vicinity

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of Ontario, no other drill holes have penetrated rocks below 1.6 km (5,200 feet). It is expected that the total Tertiary and Quaternary rocks at Ontario may not be as thick as at the Highland No. 1 location, but post-Miocene faulting may have produced a thicker Pliocene Idaho Group section at Ontario.

The surface geology in the vicinity of the Ontario property of Ore-Ida is relatively simple. Quaternary alluvium and terrace deposits crop out over a radius of about 6.5 km (4 miles) around Ontario, and the alluvium is even more extensive where the Snake and Malheur Rivers join, to the south. The alluvium and terrace deposits do not display evidence of recent faulting, except through extrapolation from the linearity of some stream channels, as may be observed on the topographic map (plate II). The alluvial material is not likely to support features in which evidence of faulting is preserved.

Bounding the Quaternary deposits are rocks of the Idaho Group, which are Pliocene in age. These rocks crop out in a broad belt for more than 20 km (15 miles) in all directions from Ontario. The Idaho Group appears to lap over the structural boundaries of the Snake River depression but becomes much thinner beyond the depression. This abrupt thinning is evident in Chrestesen No. A-1, S. 29, T. 11 N., R. 3 W.

The Idaho Group has been divided into formations by some authors. The formation names do not extend with consistency across the Oregon-Idaho boundary, for rock units which are obviously lithologically and stratigraphically similar. In fact, equivalent units have been given different names when they have been deposited in adjacent basins separately by minor highlands.

In eastern Oregon the stratigraphic succession within the Idaho Group is, from youngest to oldest, "Coarse-grained Basalt," Chalk Butte Sediments and Basalt Flows, Grassy Mountain Basalt, Grassy Mountain Sediments, and Kern Basin Formation. In Idaho the group includes the Black Mesa Gravel, Bruneau Formation, Chalk Hills Formation, Banbury Basalt, and Poison Creek Formation. The group may total more than 2 km (6,300 feet) in thickness in interior grabens within the main Snake River depression but may be less than 1.2 km (4,000 feet) thick at interior horsts. It appears from well logs and also is reported from the active seismic surveys conducted for this project (Appendix 1) that the Ontario area is a local graben with Idaho Group rocks more than 2 km (6,300 feet) thick. Southward, well logs indicate that a horst occurs, trending northwesterly, and Idaho Group rocks may be thinner than at Ontario. Private

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seismic records support this conclusion (Applegate, personal communication, 1978).

Within the Idaho Group, the principal lithologies are tuffaceous claystone, tuffaceous sandstone, sandstone, shale, siltstone, basalt and some interbedded conglomerates. In some areas, the basalt flows may comprise a formation nearly 300 m (1,000 feet) thick, which has been called the Grassy Mountain Basalt, but the seismic data obtained at Ontario did not indicate significant basalt flows within the first 2 km (6,300 feet) below surface. A reflector horizon identified by the seismic survey at about 250 m (800 feet) depth which was probably basalt was neither thick nor continuous. We may conclude that the Grassy Mountain Basalt will not be a factor influencing the geothermal resource at Ontario. The reservoir rock at depths where the temperature is sufficiently high for production interest will be Miocene basalts of the Columbia River Group.

Initially, it was calculated that the Columbia River Basalt (equivalent southwestward is the Owyhee Basalt) would be encountered at a depth of less than 1.7 km (5,500 feet) below surface at Ontario. The seismic survey identified seismic basement, a strong reflector horizon, at about 2 km (6,200 to 6,300 feet) depth. It is probable that this seismic basement is the Columbia Basalt.

The seismic survey sections do not penetrate the reflector horizon to determine thickness of the basalt or nature of the materials underlying the basalt. The survey did suggest that the reflector horizon had significant relief. The relief may be either structural or erosional. The tectonic history of the area suggests that the relief is structural.

Total thickness of the Columbia River Basalt flows at Ontario is not known. A recently drilled well 12 miles northeast of Ontario, outside of the Snake River depression, intercepted about 1.9 km (6,000 feet) of basalt flows, below about 100 m (300 feet) of Idaho Group sedimentary rocks, with only minor interbedded tuffs and volcaniclastic rocks interbedded with the basalts. This same thickness has been measured in surface outcrops north of Weiser. Southward from Ontario, in the logs of deep drill holes, there has been a less thick section of the basalt observed. At the James No. 1 well site, S. 27, T. 4 N., R. 1 W., the basalts are less than 1 km (3,000 feet) thick. The basalts are also less than 1 km (3,000 feet) thick in the subsurface at the Highland No. 1 drill hole.

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The Columbia River Group characteristically is split into two series of flows by tuffs and lacustrine sediments with varying thickness. The pyroclastic and sedimentary rocks have been named the Payette Formation (stratigraphic equivalent of the Sucker Creek Formation). Ontario was at the approximate center of the location of Miocene Lake Payette, and the Payette Formation name may be preferable to Sucker Creek in this area. The tuffs and lacustrine rocks are as much as 700 m (2,200 feet) thick. Another 1 km (3,000+ feet) of basalt flows may occur below the Payette Formation. In the James and Highland holes, there are at least 1 km (3,000 feet) of shale, silt, tuff and interbedded basalt flows below the thick section of flow-on-flow basalts which mark the upper part of the Columbia River Group. Southward and eastward into Idaho, felsites become more frequent. A silicic volcanic assemblage in that area originates in a magmatic regime with different composition.

The stratigraphic column presented by Corcoran and Newton (1963) may be applied to the Ontario area. It is compatible with the drill hole records and sections supplied by these authors as well as the column constructed by Warner (1977). A stratigraphic column after Corcoran and Newton is shown in figure H-1. The geologic cross sections (fence diagrams) of plate III also are after Newton and Corcoran, with the added stratigraphic information from recent drill hole logs and the seismic data from Applegate (1978).

Seismic Reflection Survey

The greatest effort and budget for collection of additional data for site selection was directed toward an active seismic survey. It was thought possible that a seismic reflection survey would inform us of two critical factors about the potential resource area. These were depth to the principal reservoir formation and degree of fracturing present in the reservoir rocks. This information could only be expected from a survey run under ideal conditions, but interbedded volcaniclastic and volcanic flow rocks do not provide ideal geologic conditions for response to seismic profiling. Nevertheless, the survey has provided valuable information.

The survey was sufficiently important that an expert seismologist was used in addition to the well-qualified seismic contractor to make independent evaluations of the field procedures, data laboratory analyses and interpretation. We therefore had the advantage from the outset of

FIGURE H-1. Stratigraphy at Ontario

Formation	Principal Lithology	Thickness at Ontario	
Quaternary Alluvium and terrace deposits	Gravel, sand, silt	0-100+ meters	Pleistocene and Holocene
Snake River Quaternary eruptives	Basalt flows	Absent	
Idaho Group, may include			Pliocene
Chalk Butte Fm./Chalk Hills Fm.	Tuffaceous claystone, tuffaceous siltstone	1,200+ meters	
Grassy Mountain Basalt/ Banbury Basalt	Dense basalt	300 meters Absent?	
Grassy Mountain sediments/ Kern Basin Fm.	Tuffaceous sediments, tuffs	100± meters Absent?	
Deer Butte Fm./Poison Creek Fm.	Tuffaceous sediments	100± meters Absent?	
Silicic Volcanics	Rhyolite flows, welded tuffs	Absent	
Columbia River Basalt/ Owyhee Basalt	Basalts	1,000± meters	Miocene
Payette Fm./Sucker Creek Fm.	Tuffs, lacustrine sediments	To 700± meters	
Columbia River Basalt (lower series)	Basalts	1,000± meters	
Idaho Batholith	Granitic, intrusions	Absent?	Pennsylvanian to Cretaceous
Paleozoic-Mesozoic Rocks	Metasediments, intrusions	Basement	

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having confirmation of many results of the survey as well as discussion and some resolution of contested interpretations.

We can make two valuable assumptions as a result of the survey. It is suggested that the first continuous basalt is that of the principal target reservoir, at a depth of about 1.9 km (6,200 feet). This conclusion is based upon agreement by the seismologists that the seismic "basement" is at that depth. This would appear to be the Columbia River Basalt Group, from analysis of the known lithologies of their region and their reaction to seismic reflection and their seismic velocities. Since anticipated basalts were not observed at depths between 1.2 and 1.9 km (4,000 and 6,200 feet), we may even assume that it is possible to project the gradient of 85°C/km from the surface to about 1.9 km, rather than to 1.2 km (4,000 feet) as in the Field Experiment Technical Proposal. This would increase the projected temperature from about 150°C to about 175°C at a depth of 1.9 km (6,200 feet), in the event there is no significant increase of rock thermal conductivity between 1.2 km and 1.9 km (4,000 and 6,200 feet). This provides additional optimism for successful completion of the field experiment.

There may be discontinuous basalts in the section above the Columbia River Group, but they would not have a net effect equal to 300 m (1,000 feet) of continuous "Grassy Mountain Basalt." The tuffaceous rocks with minor interbedded flow basalts of the Idaho Group would then consitute a low conductivity insulator for 1.9 km (6,200 feet) over the reservoir rocks.

There is some difference of opinion between the seismologists about the number and precise location and direction and dip of some faults in the Ontario area, but they agree that faults occur. In some instances there is agreement about the precise location, direction and dip. It was not previously known that there were any major fractures or faults in the vicinity of the Ore-Ida property and leased areas. The seismic data in some instances are so strong as to leave no doubt that faults occur, albeit with minor displacement. Where data is poor and/or there is disagreement between seismologists about interpretation of the data, there still may be large fractures and joint systems with little displacement. Plate IV provides a synthesis of the conclusions from the seismic survey interpretations.

The presence of faults and fractures is still considered important to the evaluation of the geothermal resource at Ontario. Open fracture systems would provide increased permeability and would transfer

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heated fluids closer to the surface. The reservoir rock is likely to be flow-on-flow basalt of the Columbia River Group. There are minor interbeds of sand and tuff in the basalt. Primary porosity in the basalts is restricted to shrinkage joints and interflow scoria and basalt rubble/loose soil zones. An individual basalt flow more than 30 m (100 feet) thick may have nearly zero permeability in its interior. It has been observed that yields are highly variable in areas where wells are producing from this unit.

Basalt flows in the Columbia River Group which have been stressed by active tectonic environments may develop closely spaced, nearly vertical open joint systems. Joints are evident in the electrical logs of wells drilled in the basalt near the active margin of the Snake River depression. The effect of fractures and major fault systems would be to increase effective porosity and permeability within individual basalt flows and also to connect the highly permeable interflow zones. Therefore, it would be advantageous to site a hole where it is known that the hole would intersect a major fracture at the projected depth of production-temperature fluid. The added permeability may be the difference between a single well which can and cannot produce 800 gallons per minute from an interval between 2.2 km (7,000 feet) depth and 2.4 km (7,500 feet) in an otherwise unfractured basalt. In an internally jointed basalt, the major fracture could reduce by several hundred meters (nearly 1,000 feet) the completion zone necessary for production. At depths below 2.2 km (7,000 feet) the cost difference may be $200,000. It is therefore of considerable advantage to locate the hole where a major, steeply dipping fracture may be projected, from geometry interpreted from the seismic data, to intersect the top portion of the reservoir.

It is also well known from study of geothermal reservoirs in many different lithologies that a major fracture system will tend to bow the isotherms surfaceward. In other words, the fracture is a permeable conduit for thermal fluids. Under pressure from the potentiometry of the hydraulic system, the thermal fluids will rise along the fault. Under some conditions, the fluids may even reach the surface as a thermal spring. Therefore, a drill site which is located so that the hole intercepts a fracture system may encounter fluids warm enough for production higher in the section than a site where the drill hole encounters normal hydraulic conditions. Again, this may lead to reduction of costs in the event a shallower hole than programmed is possible.

The detailed results of the seismic reflection survey are described in Appendix 1 of this report. This represents the final report which the

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seismic contractor submitted. A separate commentary about the data reported by the processing laboratory is provided as Appendix 2. The commentary uses the same reference numbers to faults and sections for convenience, although the commentator may disagree with the actual existence of the faults.

Wherever there is reasonable doubt about existence of faults after synthesis of the two interpretations of the seismic data, it appears preferable to assess the potential drill site locations as if the fault does not exist. This is decidedly a conservative view. The faults which are controversial probably do exist in some form of fracture or joint system. However, it is critical that their geometry be accurately known before these structures can be projected to the depth of the target reservoir at the place where production temperatures are reached, in order for them to be useful. This cannot be done with the existing data for some proposed faults.

Suggestions have been made that additional information should be sought by running additional seismic lines to cover the area where results were poor. There is no guarantee that new efforts will produce better data. In fact it is almost assured that a new survey would have to employ larger explosive charges buried at greater depths to have a good chance of better data recovery. Such a survey would probably cost upwards of $10,000 per line 1.6 km (1 mile). It would be difficult to obtain environmental agency approvals and permits from land owners for the deep drilling and large explosive charges. Additional seismic surveys are therefore not recommended.

Based on the interpretations of the seismologists who have reviewed the seismic data, two preferred locations for the proposed drill holes are recommended. The first location, in order of preference, is at the southeast part of Ontario, in the SE4, SW4 Sec. 10, T. 18 S., R. 47 E. A location north of the center of the section should intersect the best known fault at a depth below 2.2 km (7,000 feet). Precise location of the drill hole may be accomplished to obtain the best combination of all factors: land control, pipeline alignment, and geology.

The second location is at the Ore-Ida property, in the vicinity of the NE4, Sec. 3, T. 18 S., R. 47 E. The imprecisely known subsurface positions of the northerly faults makes precise location of the secondary drill hole on the basis of geology impossible. It would be logical to select the location based upon construction considerations. The location proposed in the Field Experiment proposal, close to the settlement ponds, is acceptable.

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It should be emphasized that except for the seismic data, coupled to suggestions of geochemistry and geomorphology, the subsurface geology is quite the same in both the southern and northern drill site recommended locations. Little displacement on the faults is suggested. The seismic data, as interpreted by consensus of seismologists, give weighty technical support to the southern drill site as the "best first shot." Poor data from the northern seismic lines had led to disagreement between the seismologists. This cannot be considered to make the interpretations of the existence, locations and dip of the northern faults any better than ambiguous. It would be providential to intersect a fault at the depth of the potential production horizon, but we could not rely upon geometric solutions.

Gravity Survey

The assembled gravity information used for the Technical Proposal for the Field Experiment showed that the Snake River Basin is characterized by a strong northwesterly grain in western Idaho and parts of eastern Oregon (plate V). The very marked en echelon west-northwesterly trending anomalies in the western Snake River depression persist into Oregon, where they are marked in the vicinity of Willow Creek, 25 km (15 miles) west of Ontario. However, the anomalies near the axis of the Snake River depression in Idaho, such as near Caldwell, are positive (gravity highs), while that at Willow Creek is negative (gravity low).

Ontario is very nearly on the trace of the axes of the positive gravity anomalies, between the high centered near Caldwell and the low at Willow Creek. At Ontario, the gravity picture is complex and unclear. Ontario is situated on a nearly featureless shelf between the Caldwell high and Willow Creek low. A slight negative anomaly at Ontario is probably explained by the deep sediments with relatively low density at the junction of the Snake and Malheur Rivers. Little more can be observed on the small scale, 5-gamma contour interval map.

Private sources have permitted the use of a 30-year-old gravity survey of the Ontario area. This survey mas made with 800-m (.5-mile) station intervals and a residual contour map was produced at scale of 1:48,000 and contour interval of 0.5 milligals. A portion of the map is shown as plate VI. The residual contour map is marked by a group of nearly circular to rectangular gravity anomalies with amplitudes between 2 and 6 milligals. The largest of these is a high anomaly at Malheur Butte. A corresponding low occurs about 1.6 km (1 mile) west of the

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Ontario airway beacon. The Ore-Ida property is on a northerly trending gradient with a slope of about 1 milligal per 1.5 km (1 mile).

The potential geothermal resource area at Ontario is located at a gently negative anomaly, sloping toward positive gravity features to the east, southeast and southwest. This is dissimilar to the potential resources areas at Weiser and Grandview, Idaho, and Vale, Oregon, which are located near positive anomalies. Moreover, the Ontario area is not associated with a known major structure, while the others are.

The lows and highs near Ontario are separated by gradients along which may be projected several northwest and west-northwest trending lines. Northeasterly trends and a northerly trend also may be observed. The reason for the distribution and shape of anomalies is not clear. They may be explained by differing depths to the basalt of the Columbia River Group, to a discontinuous younger basalt or other dense rock or to differing composition, degrees of compaction and thickness of the deep sedimentary rocks.

The gradients may mark the approximate location of discontinuities or faults. The shallow portions of faults determined by the seismic survey do not appear to be supported by gravity gradients, but there is one northwest-trending gradient about 2.5 km (1.5 miles) south of the airport, which may mark displacement of basement on the faults indicated by the seismic survey. The gravity map is not sufficiently detailed nor are stations sufficiently close to be compatible in the seismic map especially if there is very little displacement on the faults.

The regional gravity map was rationalized in the field experiment proposal as a northwesterly grain imparted by the large tectonic feature of the basin and by internal components of the basin--fracture zones and changes from high to low density rocks.

Northwest-trending, discontinuous, subparallel faults with individual faults to 20 km (12 miles) in length mark the northern and southern boundaries of the Snake River Plain. No clear evidence exists for the presence of right-lateral strike slip faults, as suggested by Lawrence (1976), or northeast-trending structures in the Snake River Plain. Gravity maps suggest that there are intragraben or intrarift faults, horsts and small grabens, oriented northwesterly. A mechanical model is an extensional couple, which would produce northwest-trending normal faults, north-northwest-trending shear fractures with normal movement and weakly developed northeast-trending fractures.

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Aeromagnetic Survey

The Total Field Magnetic Anomaly Map (plate VII) produced for this project from the data banks by the Geophysics Group at Oregon State University in 1978 has several interesting features. Significant area-wide trends as well as local features are observed in the 430 square km (130 square miles) within the map boundaries.

A very steep regional gradient appears with magnetic highs to the east. There is a decline from as much as 300 gammas in the east to zero (0) gammas in the west.

Within this overview, there is a linear magnetic high which runs northward from the western side of Ontario for about 14 km (9 miles). Closure on this feature is about 40 gammas within 2.6 km (1.7 miles) distance to the east and west. It is not possible to rationalize this magnetic anomaly from the observed geology. It may reflect a buried fault, with west side up, bringing volcanic rocks surfaceward.

Two negative magnetic features occur on the map, centered about 4 km (2.5 miles) east and 14 km (9 miles) north of Ontario (center). The anomaly just east of Ontario coincides with the deep sediments at the confluence of the Malheur and Snake Rivers. It has a diameter of 6 km (3.5 miles) of closure, with relief of about 20 gammas. The second negative feature extends northward, off the mapped area. It has closure of about 10 gammas. The two features can be connected by a northerly oriented axial line. The trace of the axis would approximately coincide with the course of the Snake River.

There is no apparent reason from surface geology for the steep magnetic high east of Ontario. Some single lines of equal magnetic intensity near the northeast boundary of the magnetic low just east of Ontario trend northwesterly, but this is very tenuous support of northwesterly trending structures. The intense gradient 12 km (7 miles) northeast of Ontario, trending northwest, may indicate fault control near the margins of the Snake River depression, but Riens Estate No. 1, in S. 9, T. 8 N., R. 3 W., shows that the Idaho Group sediments are 1.4 km (4,800 feet) thick 22 km (14 miles) east of Ontario.

We may classically assume that the linear to circular high magnetic anomalies in the Ontario area signify relative thinning of nonmagnetic sections of sedimentary rocks, positions of Quaternary basaltic eruptive centers and diabasic intrusive masses. Intense gradients bordering magnetic highs and lows may indicate fault control. It is

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difficult to assign these classical conditions to any of the magnetic anomalies at Ontario.

Hydrogeochemical Survey

A hydrogeochemical survey of the area produced some interesting, if slightly ambiguous, results. Samples were obtained from 10 wells in the Ontario and Payette areas and 2 wells/springs at Weiser.

The wells in the Ontario and Payette areas had SiO_2 concentrations between 41 and 73 mg/l. This cannot be considered indicative of a thermal reservoir leaking toward the surface, even if we credited cold water mixing.

At least 3 wells at Ontario and 1 well at Payette had waters with anomalously high chloride (Cl). The wells at Ontario (O-I-3, O-I-5, O-I-8), in Sections 7, 4 and 10, T. 18 S., R. 47 E., are wells with high total dissolved solids (TDS). These wells also have high sulfate (SO_4) concentrations. All of these wells are within less than 1 km (0.6 miles) north and south of the 1.9 km (6,200 feet) depth projection of the most prominent fault located by the seismic survey. It must be stated that other wells might also have high TDS, Cl and SO_4 concentrations but that the sampling represents too small a statistical group. However, we must also consider that the chemistry of these wells indicates leaking from a thermal reservoir. If so, the favorable feature is that the thermal reservoir or reservoirs exist. The unfavorable feature is that the leakage may mean that the rocks of the Idaho Group have a less insulative character than attributed to them. If the Idaho Group is more conductive than lithology indicates, then the temperature gradient may be less than the 85°C/km anticipated. The geochemical information is not adequate to change the original gradient projections.

The hydrochemical data accompanies this report as Appendix 3 and is shown on the topographic map, plate II.

It is of interest to compare the general chemistry of the waters sampled at Ontario with the thermal waters at Weiser. At Ontario the low TDS well waters (equal to or less than 500 mg/l TDS) are confined to two holes, O-I-6, with TDS of 308 mg/l, and O-I-4, with TDS of 330 mg/l. Both are within less than 0.5 km (0.3 mile) of the Snake River. These are Na-Ca-HCO_3 waters at O-I-6 and Ca-Na-HCO_3 waters at O-I-4.

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At Ontario, waters with high TDS and/or thermal waters are Na-Ca-HCO_3-SO_4 in nature. Ca may occasionally equal Na. This also describes the high TDS and/or thermal waters in the Weiser area. In some of the hot springs at Weiser, SO_4 and Cl may have greater concentrations than HCO_3.

The waters at Ontario have unusually high concentrations of Mg, in the case of most of the wells sampled. Only well O-I-2, south of Payette, has less than 5 mg/l of Mg. By contrast, the great majority of waters sampled in the Weiser area have very low Mg, often less than 1 mg/l. This may be accounted for by the greater amount of fragmental basic volcanic lithologies in the subsurface at Ontario than at Weiser.

There are no strong indications from the geochemistry of waters collected at and near Ontario that a powerful hot water reservoir occurs in the subsurface. This is not surprising and is not a strong negative comment about the potential for producing hot water below electrical generating temperatures. It is reasonable to assume that a hot water reservoir occurs at depth and that water rises from the Columbia River Group flows into the overlying volcaniclastic rocks and heat is broadly dissipated into the thick insulator. No convection cell appears to be formed. In this case, we would expect to see only weak suggestions in the hydrogeochemistry of a thermal system. It was hoped that the geochemical survey would combine with the data developed by the seismic survey and geologic analysis to indicate fracture leakage zones from the deep thermal reservoir. This may be suggested by the chemistry of the waters distributed in wells near the projection of the proposed fault in the southern part of Ontario.

The small amount of chemical data developed do not provide assistance in estimating reservoir base temperature nor in indicating direction, velocity and age of the water in the deep reservoirs.

Heat Flow

A heat-flow analysis has been compiled for the Snake River Plain by Blackwell from temperature-gradient hole information, temperatures measured in stabilized wells, and laboratory measurements of thermal conductivity of recovered rock cores and chips (figure 2). Ontario is within a zone of 2.5 Heat Flow Units (= 2.5 microcalories per square centimer per second). Heat flow is determined by the formula:

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Heat flow (Q) = $k\frac{dt}{dx}$, where

k = rock thermal conductivity, in situ (includes porosity and fluid conductivity corrections)

$\frac{dt}{dx}$ = temperature gradient, degrees C per kilometer (= DT)

With knowledge of any two of the factors, the third may be calculated.

At Ontario, a shallow gradient hole has determined a temperature gradient of between 80° and 90°C/km. Other holes in the area confirm that we can expect this gradient to persist to depths of at least 1.2 km (4,000 feet), before changes from sedimentary rocks with k = 3.2 (average) to volcanic rocks with k = 5.0 to 6.0 probably occur. The effect of higher k would be lower DT. The DT is estimated conservatively to 55°C/km for the zone from below 1.2 km (4,000 feet) to 1.5 km (5,000 feet) and 48°C/km for the zone below 1.5 km (5,000 feet). Using these estimates, a synthetic gradient at Ontario would be:

1. Surface to -1.2 km (-4,000 feet) at 85°C/km = 10° + 104° = 114°C.

2. -1.2 km (-4,000 feet) to -1.5 km (-5,000 feet) at 55°/km = 114° + 17° = 131°C.

3. -1.5 km (-5,000 feet) to -2.2 km (-7,000 feet) at 48°/km = 131° = 29° = 160°C.

Thus, we could anticipate a temperature of 160°C (= 320°F) at a central target depth of 2.1 km (7,000 feet). It is unlikely that the temperature would be less than 150°C (300°F) nor is it likely that the temperature would much exceed about 175°C (350°F) at that depth. In the event that seismic basement at 1.9 km (6,200 feet) is the first major basalt, the sedimentary rock average k = 3.2 may persist to that depth. The effect of this would be to raise the gradient between depths of 1.2 km (4,000 feet) and 1.9 km (6,200 feet). Consequently, the temperature at 1.9 km (6,200 feet) would be about 175°C. Thin, discontinuous basalts high in the section would not alter this estimation, but continuous basalt flows more than 59 m (150 feet) thick conceivably could drain hot water flow and reduce the gradient to nearly isothermal conditions below the basalts.

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There is evidence from the Chevron Highland No. 1 gas and oil wildcat exploration hole in T. 6 N., R. 5 W., S. 24, that the conservative synthetic gradient constructed for Ontario is quite reasonable. The Chevron hole was drilled to a depth of 3,646 m (11,963 feet). An overall average gradient of 61.2°C/km was obtained to a depth of 3,246 m (10,650 feet), based upon temperature measurements of 210°C at that depth. The Chevron hole is located in a zone with average regional heat flow of 2.0 to 2.5 HFU, according to Blackwell, which is less than the average heat flow at Ontario.

Figure H-2 clearly shows the parallelism between the northwest-trending structural anomaly of the Snake River depression and the heat flow anomalies. The central axis of the rift zone appears as an anomalously low heat-flow zone. There, the average heat flow is about 1.5 ucal/cm^2/sec. (- 1.5 HFU). The low anomaly may be caused by masking of gradients by thick, young, central basin formations saturated by cold water or may represent real reflections of lateral distance from heat sources. The upper part of the crust may be thinner than normal in the Snake River Basin, providing a high regional gradient.

Distributed in an en echelon northwest-trending pattern along and southwest of the regional average 1.5 HFU area are a series of high heat-flow anomalies. In the anomalies, 3 HFU are exceeded. In Oregon, small areas of high heat-flow anomalies are found in the vicinities of Vale and the Bully Creek-Cottonwood Mountain areas west of Ontario. Another is located in Dry Gulch, between Ontario and Jamieson. The anomalies in Oregon are long, narrow features apparently associated with faults. The faults mark the boundaries between basin and horst blocks beyond the main Snake River depression.

There is no specific, clearly founded heat-flow anomaly associated with Ontario, Oregon. Ontario is located in a broad zone of average 2.5 HFU. Some values approaching 3.0 HFU are also found in the zone. The shape of the zone including Ontario is an inverted "u," with the base ending at the Bully Creek and Weiser areas. The zone appears to follow the shape of the western Snake River Basin and indicates, as do geology and other geophysical surveys, that the main basin terminates about 15 miles northwest of Ontario.

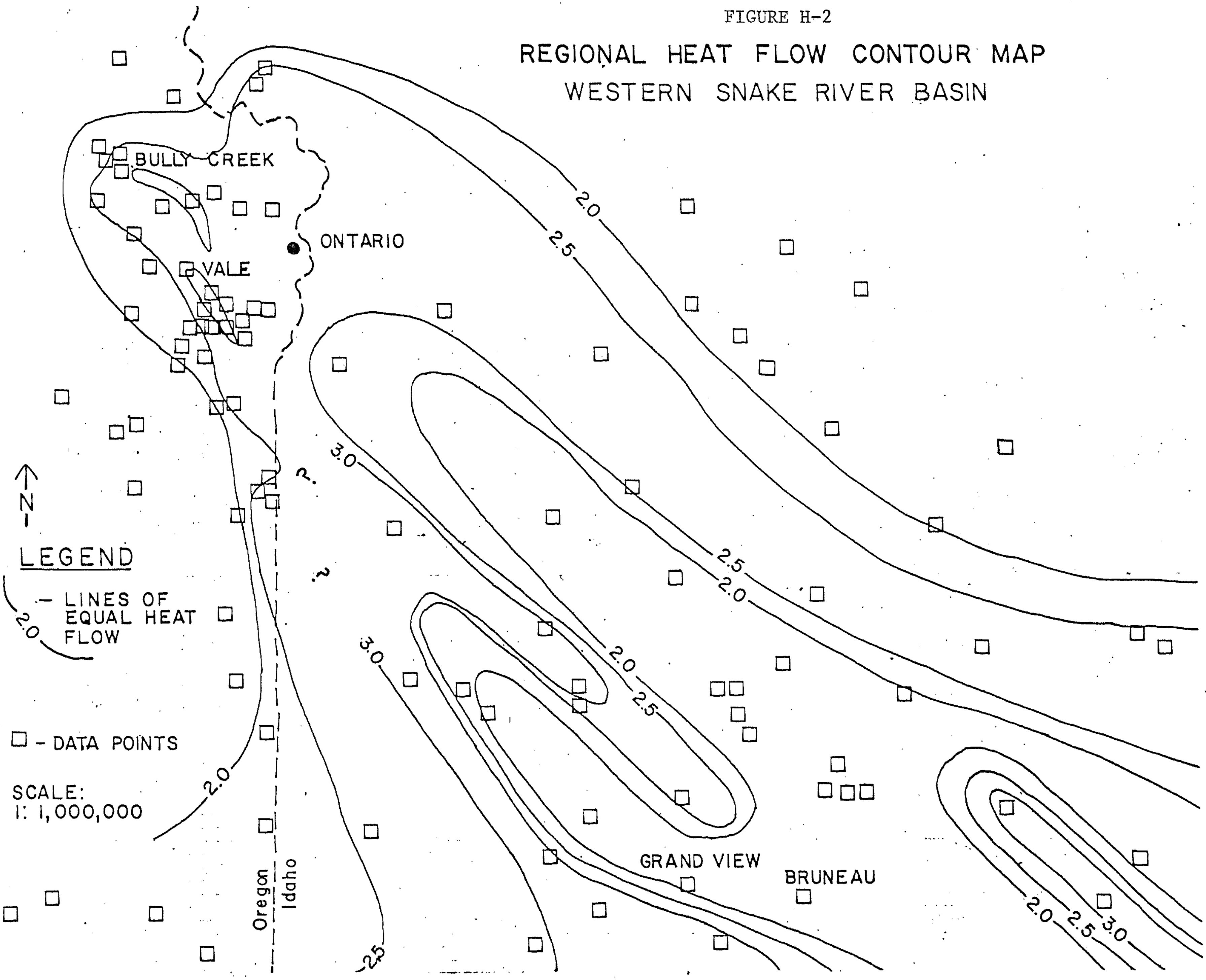
POTENTIAL SITES

Two areas have been identified as potential sites for the first exploratory drill hole for the Field Experiment. The objective is a

FIGURE H-2

REGIONAL HEAT FLOW CONTOUR MAP

WESTERN SNAKE RIVER BASIN



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production well. Identification of a reinjection well location is a secondary objective. One location is in the southern part of Ontario and one is in the northern part of Ontario. The technical support, from the seismic survey, is considerably stronger for the southern site. Consequently it is referred to as the primary site and the northern site is referred to as the secondary site.

Primary Site

The primary site is an area defined by geometric projection of fault III to a depth of 2.2 km (7,000 feet). This has been done using the limits of dip of the fault plane as 65° and 80° northeastward. The result is a zone about 600 m (1,800 feet) wide from southwest to northeast, as indicated on plate IV.

The area is bounded by the freeway (I-80) on the east and may be extended west-northwestward to the campus of Treasure Valley Community College. The fault zone persists further westward but would be beyond a 3.2-km (2-mile) limit from the Ore-Ida plant site beyond the community college. It is proposed that there is greater geological likelihood that the fault is at an average dip closer to 65° than 80°. Therefore, a site is recommended east of the Union Pacific Railroad lines between the approximate projection eastward of 7th and 9th Avenues. The area least developed, east of 4th Street, is probably most advantageous for communication with the plant site. The area has been indicated on the map (plate IV). In summary, it represents the projected intersection of the fault identified by seismic reflection survey with the potential reservoir formation (Columbia River Group) at a depth where the synthetic gradient indicates that a temperature in excess of 150°C occurs.

Secondary Site

The secondary site is at an area defined by the similar solution by descriptive geometry at the location of possible faults IV and V at a depth of 2.2 km (7,000 feet). Neither, either or both of these faults may in fact exist, according to the views of the seismologists who interpreted the seismic reflection data sections.

Again, the limits of 65° and 80° northeastward dip have been used for the faults. There is an area immediately north and east of the freeway bounded by Flynn Road on the northwest which is the zone between the

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projection of faults IV and V at dips of 65° northeast to 2.2 km (7,000 feet). This zone is about 500 m in width, from southwest to northeast. It coincidently includes the proposed production well sites 1 and 2 as shown on the Ore-Ida Facilities Site Plan, figure 3 in the Field Experiment Technical Proposal, Volume I. It is indicated on the map (plate III). A site is recommended on the Ore-Ida property which provides best communication with the proposed location of the plant heat exchanger site, the settlement lagoons for waste disposal of fluids during testing, and least problems relative to freeway and environmental considerations.

Summary

The primary site is recommended as the first choice for an exploratory hole entirely for technical reasons. The secondary site is recommended as an alternative because of proximity to the plant, property ownership communications and environmental considerations. It is recommended that the best technical shot be attempted first, inasmuch as the resource must be located and tested before pipeline costs and other factors are pertinent as long as the additional land acquisition, pipeline costs and route environmental constraints are not absolutely prohibitive.

Finally, it is possible to convert the primary site from a production well into a reinjection well site, in the event that the primary site is drilled successfully and followed by a second hole at the secondary site which also produces sufficient amounts of thermal fluid at acceptable temperatures. The reasoning is that the secondary site would be drilled with the intention to be used as a reinjection hole but targeted to the production depth. It would be tested just as the primary site. Correct exploration procedure is to drill the best technical location first, unless it is agreed in advance that there will be a second effort regardless of the results of the first drilling effort. It is assumed that the primary site may be objectionable because of the cost of construction of a pipeline for testing and delivery purposes. A pipeline for exclusively testing and transport of fluid for reinjection purposes would be somewhat less costly.

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APPENDIX 1

SEISMIC REFLECTION STUDY

OF THE

ONTARIO, OREGON, AREA

October 1978

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SEISMIC REFLECTION STUDY OF THE ONTARIO, OREGON, AREA

Introduction

During the summer of 1978, a high-resolution seismic reflection study was undertaken of the Ontario, Oregon, area. The purpose was to map possible structural controls on the postulated geothermal system. It was anticipated that the geothermal system relies on an insulating blanket model of sediments and volcanics (Applegate and Donaldson, 1977) to provide a significantly higher than normal geothermal gradient. The actual geothermal reservoir would, perhaps, be localized by faulting. This structure should be detected by the seismic reflection study.

Field Techniques

The high resolution seismic reflection method is a slight modification of standard petroleum exploration techniques. The primary modifications are closer detector spacings and smaller charges resulting in higher frequency data. The closer detector spacings minimize spatial aliasing and allow a more vertical travel path for the seismic energy. Smaller charges yield a higher percentage of high-frequency energy.

For the Ontario study, a detector spacing of approximately 100 ft was chosen as a compromise to allow the detection of deeper structures while taking advantage of the stacking technique's unique properties, and yet still allowing the mapping of shallow structure. The charge size was kept small to enhance the high frequencies, to attempt to avoid "ringing" of volcanics, and due to logistical constraints.

Two major problems were anticipated and indeed present. These were complex geology--interbedded volcanics and sediments--and logistical problems including utilities and traffic. Every effort was made to design the field techniques and processing techniques to minimize the geological noise, and numerous precautions were taken to minimize the effects of utilities and traffic.

The field equipment utilized was a Quantum Electronics DAS-1 digital recorder. Data were recorded in digital form on magnetic tape with a low-cut filter of 50 hz and an anti-aliasing high-cut filter. The sample interval was 1 ms. The detectors were a single 30-hz geophone per channel. The data were recorded 6-fold. The energy source was from 0.4 to 0.8 lbs of 75% dynamite in 10-ft deep drill holes.

Data Processing

Data processing was subcontracted to Applied Research Concepts, Inc. (ARC), Houston, Texas. The processing sequence began with demultiplexing and reformatting. The data were then sorted into common depth point gathers. Then a number of different processes were applied to enhance the data. Two complete processing runs were made. The output of the first run was utilized in modifying the processing sequence. Static and normal moveout corrections were made to correct the data for elevation variations and also for the geometry of the seismic spread. Other processes included deconvolution. Deconvolution in effect shrinks the seismic wavelet so that the resolution is improved. The data were filtered with a time-variant filter. The purpose of the time-variant filter is to minimize noise that is not part of the seismic signal. Autostatics were also applied to correct for any inadequacies in the regular statics program. Then the data were stacked (6-fold) to enhance the signal-to-noise ratio. The stacking velocities were determined from velocity analyses at approximately every fifteenth shot point.

Interpretation

Six seismic lines were shot to approximate the outline of a box around Ontario. Due to logistic constraints, the corners of the seismic lines were not tied, so it was extremely difficult to map any horizon completely around the box.

Approximately 10.5 miles of seismic data were acquired. The data quality ranges from poor to good. In general the shallow data are good, while the deeper data are of poor quality. Several fault structures were mapped with varying degrees of confidence.

Each of the seismic lines is discussed individually. Fault breaks are graded from A (very good) to D (very poor). These data are then incorporated on a fault map (plate I).

Line A is of little use. The data are generally poor, except for some alignments shallow in the section. On the basis of these poor data, one questionable fault (VII) (grade D) was picked.

Line B is a north-south line. The southern portion of the line is straight while the northern part curves along the river. The data quality is generally fair. Line B has a possible fault (IV) (grade B) at the south end of the section. Another interpretation indicates the anomaly but would rank the fault more questionably. Correlative geomorphologic data are two very parallel and very straight drainages on the east side of the Snake River. Based on this evidence, we believe there is a good possibility that the fault exists. Preliminary data processing showed an additional, parallel feature in the immediate vicinity. However, later processing obscured this feature. The northern part of line B is poor. However, there are some possible fault indications. None appear to be definitive enough to support themselves.

Line C is reasonably good throughout its length and has the best quality data at depth. Three faults of varying quality are indicated on the seismic section. The easternmost fault (VI) was rated B- to C+. However, the amount of offset is very minor and could possibly represent a small roll-over, especially in the shallow section. The middle fault (V) is given an A rating and is indicated by reflection terminations, some possible diffractions, and some roll-over into the fault. The control on this fault appears to extend it clearly into "seismic basement" at a depth of approximately 6,000 ft. The "seismic basement" appears to be massive volcanics, due to similarity with characteristics in other locations where the contractors have worked. The westernmost fault (IV) on line C was given a B rating. Again the throw is minor in the shallow section, but the fault appears to offset "seismic basement." Another interpretation yields significantly different results using the same evidence. However, we feel that our interpretation is compatible with all data indicated.

Line D clearly has the worst data. Only a very few alignments are seen. However, one very poor fault (VI) (grade D) is indicated.

Line F is of reasonable quality throughout. Three significant faults are indicated, and some subsidiary faults are possibly present. Spatially these faults are not well controlled because they cross the line at rather low angles, which tends to smear the contact. The easternmost fault (III) (grade A) is down to the east and is the best controlled fault on the line. Some ambiguity results from the relationship of apparently subsidiary features that appear to feather into the main trace. The two western faults on the line create a relatively broad zone of poor data. The western fault (I) (grade A) is down to the west and is only moderately constrained. An additional west-side down fault (II) may be slightly east of the western fault on line F. This is suggested by data from line H. These two western faults may represent a zone of faulting or merging of the two faults at depth.

Line H is a line of excellent quality data in the shallow section. Three faults are indicated on this line. The southernmost fault (I) (grade A) is down to the south and its location is constrained to a depth of approximately 2,600 ft. The center fault (II) (grade B) is down to the south also and may merge into the southernmost fault at depth. The northern fault (III) (grade A) is down to the north and is reasonably well constrained. The data on this line and on some additional lines suggest that there may be some thin interbedded volcanics in the shallow section (at a depth of about 650 ft on the southern part of line H).

The map (plate I) shows the faults as they are projected to the surface, as well as the most plausible manner of connecting the faults into a regional fault pattern. A number of factors are considered in the procedure of connecting various fault breaks. Some of these are: (1) the character of the faults (throw, dip, and apparent age), (2) the pattern of the fault breaks (direction of throw), and (3) other data on the structural grain of an area. Regional trends of geomorphic expressions and mapped faults with strikes of N55°W to N60°W were observed and incorporated in the analyses.

The southern set of three faults is well constrained. These three faults (I, II, and III) appear to define a prominent horst block with a NW-SE trend. These faults appear to fit well with the regional geologic trends. Displacements for these features are indicated on the map where they were picked. Since the displacement may vary with depth, the depth from which the value is obtained is also indicated.

Faults IV and V are the next ones further north, and the reliability is less due to less control on the features. Fault IV is relatively well defined on line B but differing opinion exists. A second fault cut on B that could correspond to fault V was indicated on the original data processing. However, additional processing obscured this cut and raised some questions on the cut for IV. The cuts on line C are also relatively well defined for both faults IV and V. Again, however, the possibility that these faults exist is questioned by another interpretation. The balance seems to be tipped in favor of their existence by other supporting evidence such as the geomorphic and regional geologic data.

Faults VI and VII are based on questionable data. Fault VI is constrained by a reasonable cut on line C and a very poor cut on line D. Both faults need additional supporting evidence to be interpreted with confidence.

Conclusions

The seismic survey defined several faults. Due to the data quality and geometric constraints, a higher level of confidence is associated with faults I, II, and III than the others. Based on the total data information, however, there is significant evidence to support faults IV and V.

Thus based on seismic evidence, one has two possible targets. One is technically better than the other due to the spatial control on the faulting. Technically the best target is north of fault III. At a slightly lower level of technical confidence is the area north of faults IV and V. Either site offers a viable target for a geothermal well.

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APPENDIX 2

Commentary on:

SEISMIC REFLECTION STUDY

OF THE

ONTARIO, OREGON, AREA

H. Thomas Ise

in association with

GeothermEx, Inc.

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INDIVIDUAL LINE DATA PRINTOUT QUALITY

1. Line "A"

   a. Quite poor data quality, can be faulted amost anywhere, but except for diffractions (?), no *positive* evidence for faulting.

   b. Sum of knowledge approximately zero.

2. Line "B"

   a. Poor to fair variable data; nothing is very clear, but probably there are no faults or shallow (0.2 second) horizon between Shot Points (S.P.'s) 18 and 42, and possibly not from S.P. 42 to 65; vague suggestion of faulting, north (??) side up, around S.P. 75.

   b. Early display strongly suggested an odd-looking down-thrown wedge between two reverse faults on south end of this line, with fault cuts at S.P.'s 7 and 17 @ 0.3 seconds; later playback almost entirely eliminates these fault-cut appearances, although there may still be a north-dipping fault (IV) at S.P. ± (@ 0.3 seconds).

3. Line "C"

   a. Definitely the best quality data we have; early playback was marred by strong multiple reflection around 0.9-1.0 seconds, which masked valid but weaker primary reflections in this zone; "stacking" with proper velocity has nearly eliminated the multiple.

   b. "Basement" shows rather nicely just below 1.6 seconds (6,000 feet), apparently nearly flat-dipping, but possibly broken by block faulting (or rough topography?).

   c. Horizon @ 0.45 seconds (1,300 feet) is not displaced anywhere along line; there is a week spot at S.P. ±, but because weakness is vertical a near-surface cause is suspected. Reflector terminating here would be stratigraphic; other reflectors correlate on character pretty well across weak zone. Good alignment of diffractions may be meaningful or coincidence and suggest a

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fault; no throw can be observed. Abrupt loss of good event at 1.34 seconds may be a fault. (This commentary indicates that GeoTechniques faults IV, V, VI are not substantiated, but V is given some credence.)

4. Line "D"

   a. Poor line, worse than "A." *No* conclusions drawn from this line should carry any weight. The attempt to put a horizon on section is very speculative. (This commentary agrees with Appendix 1, except to discount fault VI.)

5. Line "F"

   a. Poor to good data; variable but generally reliable in shallow part of section.

   b. Most notable features are faults, well defined at S.P. 40 (III), fair @ S.P. 84 ± (I), and poor @ S.P. 63 ± (II). All cuts are at approximately 0.2 seconds. Throw on "III" seems well defined by character of reflectors and location by roll-over and termination of reflectors; at depth it is dependent on diffractions and a few terminations. "I" is not clear because it is in an area of poor data but shows some roll-over and diffractions. "II" is defined shallow by fair roll-over and termination of one reflector, and comes down into a swarm of diffractions.

   c. "Basement" may appear locally around 1.5 seconds on the west end of the line and again under S.P. 90 at the same time (?) and much shallower (1.25 seconds) under S.P. 20. The latter pick is questionable because of its high position (4,200 feet ±).

   d. A good reflector, near 0.1 second on the west end, could be basalt (based on strength and frequency) (?) and is apparently not seen on other lines. It would project (on the dip seen) to the surface about three miles west of the end of the line, about one mile east of Malheur Butte.

6. Line "H"

   a. Fair to good data at shallow depths but very little deep information. There are numerous apparent diffractions.

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b. Faults are prominent features. "III" and "I" are well defined and look remarkably like their counterparts on line "F." "II" is less well defined, but the displacement is indicated by the shallow reflector. Diffractions help define "III" and "I" with depth. Apparent dips are: "III" = 70° ±, "II" = 55° ±, and "I" = 55° ±. These are close to true dips because line "H" is nearly at right angles to the faults.

c. "Basement" may be seen between S.P.'s 82 and 85 at 1.64 seconds (below 6,200 feet). On any of the sections, I cannot relate "basement" apparent faulting with the shallow section, so an unconformity is implied, or at faults which do not persist into the younger beds.

Map 1 is a structure-contour map in two-way vertical time to the shallow reflector horizon. It suggests a very gentle dome under Ontario with broad, very gentle east dips. Another dome is implied at the south end of line "H." The traces of the faults considered probable are shown for this horizon.

Map 2 shows structure contours on the three most probable faults at arbitrary planes below the seismic datum. There is thought to be a range of possible error in dip on all faults less than 5° but possibly as much as 10°.

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APPENDIX 3

GEOCHEMICAL FIELD DATA REPORTS

AND

LABORATORY ANALYTICAL DATA SHEETS

FIELD DATA RECORD - WATER SAMPLE

Source Name: CITY WELL 14

Sample No. ORE-IDA 1

Aliquots: ✓Fu; ✓Fa; Fda; Ru; Ra*

Location: PAYETTE, CENTER AVE AT 21ST ST.

Date: 18 JULY '78 Sampler: MAT

Sample Data:

Temp. 16 °C. °F.

water color/clarity: CLEAR, COLORLESS

where measured: SPIGOT NEAR PUMP AND WELL HEAD: WELL PUMPED 15 MIN BEFORE SAMPLE AND FIELD MEASUREMENTS TAKEN.

odor: NONE

Discharge: 225 gal/m ~~1pm~~

gas: NONE

Well data:

X pumped sample; ____ flowing(artesian)

total depth: 279 ft.

depth to water:

Component	Sample type*	Conc.,ppm	Measured in field	other(when)	Method; comments
Sp.Cond.	R	750 μm	✓		HACH
pH	R	7.5-7.8	✓		
SiO_2					HACH
Cl		100 mg/l	✓		HACH
NH_3		.9	✓		HACH
F					

Other conditions of source: (contamination, mineral deposits, geologic setting, sketch, etc.)

none observed

* F = filtered; R = unfiltered; u = untreated; a = acidified to pH 2
d = diluted 1:10 with distilled water

FIELD DATA RECORD - WATER SAMPLE

Source Name: CARPENTER GAS WELL

Sample No. ORE-IDA 2

Aliquots: ✓Fu; ✓Fa; Fda; ✓ FuD 1:3 Ru; Ra*

Location: PAYETTE, NEAR BEND IN PAYETTE RIVER

Date: 18 JULY '78 Sampler: MAT

Sample Data:

Temp. 19 °C. °F.

water color/clarity: VERY SLIGHT GREY COLOR – HARD TO TELL BECAUSE OF ORGANIC MATERIAL – ALGAE

where measured: REMOVED ROCKS PLUGGING CASING ~2 ft. IN 1 HR WATER RAISED ~3/4 ft. – SURFACE

odor:

Discharge: <1 lpm

CASING DIA. ~6"

gas: YES – DRILLED FOR GAS WELL IN 1955 BY OMOCO – BUBBLING IS MODERATE – STRONG.

Well data:

pumped sample; flowing(artesian)

total depth:

depth to water:

Component	Sample type*	Conc., ppm	Measured in field	Measured in other(when)	Method; comments
Sp.Cond.	R	2040 μm			HACH
pH	R	~8.0			
SiO_2					HACH
Cl		450 mg/l			HACH
NH_3		8.0 (DILUTED 1:4)			HACH
F					

Other conditions of source: (contamination, mineral deposits, geologic setting, sketch, etc.)

IN RIVER PLAIN

CONTAMINATED WITH ALGAE

* F = filtered; R = unfiltered; u = untreated; a = acidified to pH 2
d = diluted 1:10 with distilled water

FIELD DATA RECORD - WATER SAMPLE

Source Name: FARMERS SUPPLY COOP WELL

Sample No. ORE-IDA 3

Aliquots: ✓ Fu; ✓ Fa; Fda;

✓ FuD 1:4 Ru: Ra*

Location: CROP DUSTING SERVICE, ONTARIO AIRPORT (WEST SIDE OF HANGERS)

Date: 18 JULY '78 Sampler: MAT

Sample Data:

Temp. 17 °C. °F.

water color/clarity: COLORLESS, CLEAR

where measured: SEE NOTE BELOW

odor: NONE

Discharge: 60 gal/min ~~lpm~~

gas: NONE

Well data:

X pumped sample; ___ flowing (artesian)

total depth: 67 ft.

depth to water: 47 ft

Component	Sample type*	Conc., ppm	Measured in field	other (when)	Method; comments
Sp. Cond.	R	2500 μm			HACH
pH	R	~7.5			LO-ION PAPER
SiO_2					HACH
Cl		550 mg/l			
NH_3		0.4			HACH
F					

Other conditions of source: (contamination, mineral deposits, geologic setting, sketch, etc.)

NOT POSSIBLE TO TAKE SAMPLE FROM WELL HEAD SO TANK WAS DRAINED AND SAMPLE TAKEN AS WATER WENT INTO TANK. PLASTIC PIPE TO TANK, TANK GALVANIZED.

* F = filtered; R = unfiltered; u = untreated; a = acidified to pH 2
d = diluted 1:10 with distilled water

FIELD DATA RECORD - WATER SAMPLE

Source Name: MUNICIPAL WELL #4 Sample No. ORE-IDA 4

Aliquots: ✓ Fu; ✓ Fa; Fda;

Location: WITHIN 50 FT OF SNAKE RIVER Ru; Ra*

Date: 19 JULY '78 Sampler: MAT

Sample Data:

Temp. 17.5 °C. °F.

water color/clarity: COLORLESS, CLEAR

where measured: H_2O LEVEL - WELL STANDING

odor: NONE

Discharge: lpm

gas: NONE

Well data:

____ pumped sample; ____ flowing (artesian)

total depth: 40

depth to water: 14

Component	Sample type*	Conc., ppm	Measured in field	other (when)	Method; comments
Sp. Cond.	R	480 μm	✓		HACH
pH	R	7.89			CORNING DIGITAL pH METER #125,
SiO_2					HACH IN WATER TREATMENT PLANT LAB
Cl		100 mg/l	✓		
NH_3		0.2	✓		
F					

Other conditions of source: (contamination, mineral deposits, geologic setting, sketch, etc.)

RUST OFF SIDES OF CASING

SNAKE RIVER WATER: 21°C

pH 8.9

TURBIDITY 38.0

H-41

* F = filtered; R = unfiltered; u = untreated; a = acidified to pH 2
d = diluted 1:10 with distilled water

FIELD DATA RECORD - WATER SAMPLE

Source Name: McDANIEL'S WELL

Sample No. O-I 5

Aliquots: ✓ Fu; ✓ Fa; Fda;

Location: JUST WEST OF FREEWAY ~ 2 MILES N. OF FREEWAY BRIDGE OVER SNAKE RIVER

✓ FuD 1:3 Ru; Ra*

Date: 19 JULY '78 Sampler: MAT

Sample Data:

Temp. 14 °C. °F.

water color/clarity: COLORLESS, CLEAR

where measured:

odor: NONE

Discharge: lpm

gas: NONE

Well data:

____ pumped sample; ____ flowing (artesian)

total depth: ~45 ft

depth to water: ~15-18 ft

Component	Sample type*	Conc., ppm	Measured in field	Measured in other (when)	Method; comments
Sp. Cond.	R	1750 μ m	✓		HACH
pH	R	7.72		IN WATER TREATMENT LAB 10 MIN AFTER SAMPLE TAKEN.	CORNING DIGITAL #125
SiO_2					HACH
Cl		300 mg/l	✓		
NH_3		0.3	✓		
F					

Other conditions of source: (contamination, mineral deposits, geologic setting, sketch, etc.)

* F = filtered; R = unfiltered; u = untreated; a = acidified to pH 2
d = diluted 1:10 with distilled water

FIELD DATA RECORD - WATER SAMPLE

Source Name: WELL ON CLARE DICKENS PROPERTY

Sample No. OI- 6

Aliquots: ✓Fu; ✓Fa; Fda; Ru; Ra*

Location: N 4873.62 E 504.70, 1 MILE NORTH OF WHERE FREEWAY CROSSES SNAKE RIVER, & 1/4 MI. EAST

Date: 19 JULY '78 Sampler: MAT

Sample Data:

water color/clarity: COLORLESS, CLEAR

odor: SLIGHTLY ORGANIC

gas: FROM DESCRIPTION BY OWNER, PROBABLY V. SLIGHT METHANE IF WELL LEFT UNPUMPED FOR SOME TIME.

Temp. °C. °F.

where measured:

Discharge: lpm

Well data:

____ pumped sample; ____ flowing (artesian)

total depth: 90 ft

depth to water: ~30 ft to 1st AQUIFER
65-70 ft to 2nd AQUIFER

Component	Sample type*	Conc., ppm	Measured in field	other (when)	Method; comments
Sp. Cond.	R	450 μm			HACH
pH	R	7.90	TREATMENT LAB, 10 MIN AFTER SAMPLE		CORNING DIG. #125
SiO_2					HACH
Cl		100 mg/l			
NH_3		14.7			SUSPECT CONTAMINATION, POSS.
F					LEAK FROM SEPTIC TANK

Other conditions of source: (contamination, mineral deposits, geologic setting, sketch, etc.)

* F = filtered; R = unfiltered; u = untreated; a = acidified to pH 2
d = diluted 1:10 with distilled water

FIELD DATA RECORD - WATER SAMPLE

Source Name: MUNICIPAL WELL ORE-IDA WELL #5

Sample No. OI - 7

Aliquots: ✓ Fu; ✓ Fa; Fda; Ru; Ra*

Location: IN FIELD N-NE OF TAPADERA MOTEL

Date: 20 JULY 78 Sampler: MAT

Sample Data:

Temp. 13 °C. °F.

water color/clarity: COLORLESS, CLEAR

where measured: AT SPIGOT NEAR WELL HEAD

odor: ? FAINT SEWAGE SMELL

Discharge: 450 ~~lpm~~ gal/min

gas: ? POSS. TRACE OF METHANE

Well data:

_____pumped sample; _____flowing(artesian)

total depth: 47 ft.

depth to water: 17 ft.

Component	Sample type*	Conc., ppm	Measured in field	Measured in other (when)	Method; comments
Sp. Cond.	R	470 μm	✓		HACH
pH	R	7.55		✓ TREATMENT LAB 11 MIN AFTER COLLECTION	CORNING DIG. #125
SiO_2					HACH
Cl		62.5 mg/l	✓		
NH_3		1.35	✓		
F					

Other conditions of source (contamination, mineral deposits, geologic setting, sketch, etc.)

BIOCHEMICAL OXYGEN DEMAND = ORGANIC WASTE, PROBABLY FROM CORN & POTATOES. SOME KIND OF GAS IS PRESENT. TWO WELLS SHUT DOWN LAST SUMMER BECAUSE GAS SO BAD.

7 WELLS CLUSTERED, BAD GAS IN TWO, 1A & 4

* F = filtered; R = unfiltered; u = untreated; a = acidified to pH 2
d = diluted 1:10 with distilled water

FIELD DATA RECORD - WATER SAMPLE

Source Name: HOLY ROSARY HOSPITAL

Sample No. OI-8

Aliquots: ✓ Fu; ✓ Fa; Fda; ✓ FuD 1:2 Ru; Ra*

Location: 351 SW 9th ST. ONTARIO, ORE.

Date: 20 JULY 78 Sampler: MAT

Sample Data:

Temp. 13.5 °C. °F.

water color/clarity: COLORLESS CLEAR

where measured:

odor: NONE

Discharge: lpm

gas: NONE

Well data:

___ pumped sample; ___ flowing (artesian)

total depth: ~40 FT

depth to water: ~20 FT

Component	Sample type*	Conc., ppm	Measured in field	other (when)	Method; comments
Sp. Cond.	R	1250 μm	✓		HACH
pH	R	8.05		✓ 15 MIN AFTER SAMPLE	CORNING DIG. # 125
SiO_2					HACH
Cl		125 mg/l	✓		
NH_3		0.4	✓		
F					

Other conditions of source: (contamination, mineral deposits, geologic setting, sketch, etc.)

* F = filtered; R = unfiltered; u = untreated; a = acidified to pH 2
d = diluted 1:10 with distilled water

FIELD DATA RECORD - WATER SAMPLE

Source Name: MITCHELL WELL

Sample No. OI-9

Aliquots: ✓ Fu; ✓ Fa; Fda;

✓ FuD 1:2 Ru; Ra*

Location: 626 MALHEUR DRIVE
ONTARIO, ORE.

Date: 20 JULY 78 Sampler: MAT

Sample Data:

Temp. 13.8 °C. °F.

water color/clarity: COLORLESS, CLEAR

where measured:

odor: NONE

Discharge: lpm

gas: NONE

Well data:

____ pumped sample; ____ flowing (artesian)

total depth: 110 ft.

depth to water: 65 ft, BETTER AQUIFER AT 70 FT.

Component	Sample type*	Conc., ppm	Measured in field	other (when)	Method; comments
Sp. Cond.	R	1240 μm	✓		HACH
pH	R	7.60		✓ 45 MIN AFTER SAMP.	CORNING DIGITAL #125
SiO_2					HACH
Cl		162.5	✓		
NH_3		9.4	✓		
F					

Other conditions of source: (contamination, mineral deposits, geologic setting, sketch, etc.)

DOMESTIC AND IRRIGATION USE

* F = filtered; R = unfiltered; u = untreated; a = acidified to pH 2
d = diluted 1:10 with distilled water

FIELD DATA RECORD - WATER SAMPLE

Source Name: TREASURE VALLEY COMMUNITY COLLEGE IRRIGATATION WELL

Sample No. OI-10

Aliquots: ✓ Fu; ✓ Fa; Fda; Ru; Ra*

Location: ON E SIDE, SECT. 9, T18S, R47E, ~½ MILE SSE OF TVCC

Date: 20 JULY 78 Sampler: MAT

Sample Data:

Temp. 14 °C. °F.

water color/clarity: COLORLESS, CLEAR

where measured:

odor: NONE

Discharge: lpm

gas: NONE

Well data:

_____pumped sample; _____flowing (artesian)

total depth: ? ~ 70-80 ft.

depth to water:

Component	Sample type*	Conc., ppm	Measured in field	Measured in other (when)	Method; comments
Sp. Cond.	R	930 μm	✓		HACH
pH	R	7.85		✓ 10 MIN AFTER SAMP.	CORNING DIGITAL #125
SiO_2					HACH
Cl		87.5 mg/l	✓		
NH_3		15.4	✓		
F					

Other conditions of source: (contamination, mineral deposits, geologic setting, sketch, etc.)

PROB. NO CONTAMINATION

* F = filtered; R = unfiltered; u = untreated; a = acidified to pH 2
d = diluted 1:10 with distilled water

FIELD DATA RECORD - WATER SAMPLE

Source Name: WEISER HOT SPRING Sample No. OI-11

Aliquots: ✓ Fu; ✓ Fa; Fda;

Location: ~5 MILES NNE OF WEISER

Ru; Ra*

Date: 21 JULY 78 Sampler: MAT

Sample Data:

Temp. 53 °C. °F.

water color/clarity: COLORLESS, SLIGHTLY MURKY, SOME DIRT AND ALGAE CLOUDING H_2O

where measured: AT ORIFICE

odor: YES (?) ORGANIC, SLIGHT SULFUR

Discharge: <5 lpm

gas: YES VERY WEAK & SPORADIC

Well data:

____ pumped sample; ____ flowing (artesian)

total depth:

depth to water:

Component	Sample type*	Conc., ppm	Measured in field	Measured in other (when)	Method; comments
Sp. Cond.	R	670 μm			HACH
pH	R	~10			Lo-Ion PAPER
SiO_2					HACH
Cl		75 mg/l			
NH_3		0.3			
F					

Other conditions of source: (contamination, mineral deposits, geologic setting, sketch, etc.)

SEEP FROM BANK INTO COLD STREAM

* F = filtered; R = unfiltered; u = untreated; a = acidified to pH 2
d = diluted 1:10 with distilled water

FIELD DATA RECORD - WATER SAMPLE

Source Name: WEISER HOT SPRING WELL SAMPLE

Sample No. OI - 11A

Aliquots: ✓ Fu; ✓ Fa; Fda; Ru; Ra*

Location: ~5 MI. NNE OF WEISER

Date: 21 JULY 78 Sampler: MAT

Sample Data:

water color/clarity: CLEAR, SOME ALGAE

odor: SLIGHT SULFUR

gas: POSSIBLY - SOME BUBBLES REPORTED WHEN WELL NOT USED FOR A WHILE & THEN TURNED ON.

Temp. 63 °C. °F.

where measured: PUMP TAKES H_2O TO POOL AT ~50-75 gal/min. THERE IS A ½ - 1 GAL/MIN OVERFLOW AT PIPE JOINT WHERE SAMPLED.

Discharge: lpm

Well data:

pumped sample; flowing(artesian)

total depth: ?? 135 FT.

depth to water:

Component	Sample type*	Conc., ppm	Measured in field	Measured in other (when)	Method; comments
Sp. Cond.	R	700 μm	✓		HACH
pH	R	~11	✓		LO-ION PAPER
SiO_2					HACH
Cl		100 mg/l	✓		
NH_3		0.9	✓		
F					

Other conditions of source: (contamination, mineral deposits, geologic setting, sketch, etc.)

* F = filtered; R = unfiltered; u = untreated; a = acidified to pH 2
d = diluted 1:10 with distilled water

FIELD DATA RECORD - WATER SAMPLE

Source Name: ORE-IDA WELL #10

Sample No. OI #12

Aliquots: Fu; Fa; Fda; Ru; Ra*

Location: NE OF FREEWAY ~ 1/8 MI., NE 1/4 NW 1/4, SECT 3, T18S, R47E

Date: 21 JULY 78   Sampler: MAT

Sample Data:

Temp. °C. °F.

water color/clarity: V. SLIGHTLY YELLOW, CLEAR

where measured:

odor: SLIGHT ORGANIC

Discharge: 250 ~~lpm~~ gal/min

gas: NONE OBSERVED

Well data:

_____ pumped sample; _____ flowing (artesian)

total depth: 100 FT.

depth to water: 12 FT IS STATIC LEVEL

Component	Sample type*	Conc., ppm	Measured in field	Measured in other (when)	Method; comments
Sp. Cond.	R	1150 μm	✓		HACH
pH	R	6.8-7.2	✓		LO-ION PAPER
SiO_2					HACH
Cl		150 mg/l	✓		
NH_3		1.1	✓		
F					

Other conditions of source: (contamination, mineral deposits, geologic setting, sketch, etc.)

* F = filtered; R = unfiltered; u = untreated; a = acidified to pH 2
d = diluted 1:10 with distilled water

LABORATORY NO:	0622-78	
DATE OF REPORT:	September 1, 1978	
IDENTIFICATION:	OI-1 7-18	

GEOTHERMEX
901 MENDOCINO AVE.
BERKELEY, CA. 94707

SPECIES	mg/L	eq/L
Ca	79.	39-4
Mg	27.	22-4
Na	63.	27-4
K	8.0	20-5
HCO_3	360.	59-4
CO_3		
CO_2(FREE)		
SO_4	81.	17-4
Cl	26.	73-5
TDS	540.	
pH	7.93	
Ec µmhos/cm @25°	811.	
Ec µmhos/CALC	895.	
Ec OBS/CALC	.906	
CATIONS Σ+		9000.
ANIONS Σ-		8320.

SPECIES	mg/L	eq/L
B	0.11	10-6 (a)
SiO_2	49.	81-5 (a)
NH_4		
F	0.29	15-6
S^{2-}		
Fe^{3+}		
Mn^{2+}		
Rb		
Li		
Sr		
Cs		
Ba		
Hg		

(a) MOLES/L

Analysis by:

H-51

AMTECH American Technical Laboratories, Inc.

8909 Complex Drive — Suite F San Diego, California 92123 (714) 560-7717

LABORATORY NO: 0622-78
DATE OF REPORT: September 1, 1978
IDENTIFICATION: OI-2 7-18

GEOTHERMEX
901 MENDOCINO AVE.
BERKELEY, CA. 94707

SPECIES	mg/L	eq/L
Ca	17.	85-5
Mg	2.0	16-5
Na	580.	25-3
K	14.	36-5
HCO_3	1100.	18-3
CO_3		
CO_2(FREE)		
SO_4	8.3	17-5
Cl	220.	62-4
TDS	1558.	
pH	8.31	
Ec µmhos/cm @25°	2410.	
Ec µmhos/CALC	2580.	
Ec OBS/CALC	0.933	
CATIONS Σ+		26600.
ANIONS Σ-		24400.

SPECIES	mg/L	eq/L
B	2.5	23-5 (a)
SiO_2	73.	12-4 (a)
NH_4		
F	0.17	89-7
S^{2-}		
Fe^{3+}		
Mn^{2+}		
Rb		
Li		
Sr		
Cs		
Ba		
Hg		

(a) MOLES/L

Analysis by:
AMTECH American Technical Laboratories, Inc.
8909 Complex Drive — Suite F San Diego, California 92123 (714) 560-7717

LABORATORY NO: 0622-78
DATE OF REPORT: September 1, 1978
IDENTIFICATION: OI-3 7-18

GEOTHERMEX
901 MENDOCINO AVE.
BERKELEY, CA. 94707

SPECIES	mg/L	eq/L
Ca	160.	79-4
Mg	80.	66-4
Na	380.	17-3
K	26.	66-5
HCO_3	570.	93-4
CO_3		
CO_2(FREE)		
SO_4	730.	15-3
Cl	250.	71-4
TDS	2076.	
pH	7.95	
Ec μmhos/cm @25°	2820.	3410.(1:10)
Ec μmhos/CALC		3650.
Ec OBS/CALC		.934
CATIONS Σ+		31800.
ANIONS Σ-		31600.

SPECIES	mg/L	eq/L
B	0.51	47-6 (a)
SiO_2	56.	93-5 (a)
NH_4		
F	0.15	79-7
S^{2-}		
Fe^{3+}		
Mn^{2+}		
Rb		
Li		
Sr		
Cs		
Ba		
Hg		

(a) MOLES/L

Analysis by:
AMTECH American Technical Laboratories, Inc.

8909 Complex Drive — Suite F San Diego, California 92123 (714) 560-7717

LABORATORY NO: 0622-78
DATE OF REPORT: September 1, 1978
IDENTIFICATION: OI-4 7-19

GEOTHERMEX
901 MENDOCINO AVE.
BERKELEY, CA. 94707

SPECIES	mg/L	eq/L
Ca	42.	21-4
Mg	16.	13-4
Na	39.	17-4
K	7.2	18-5
HCO_3	190.	31-4
CO_3		
CO_2(FREE)		
SO_4	68.	14-4
Cl	24.	68-5
TDS	330.	
pH	7.93	
Ec µmhos/cm @25°	505.	
Ec µmhos/CALC	559.	
Ec OBS/CALC	0.904	
CATIONS Σ+		5300.
ANIONS Σ-		5210.

SPECIES	mg/L	eq/L
B	0.11	10-6 (a)
SiO_2	34.	56-5 (a)
NH_4		
F	0.74	39-6
S^{2-}		
Fe^{3+}		
Mn^{2+}		
Rb		
Li		
Sr		
Cs		
Ba		
Hg		

(a) MOLES/L

Analysis by:
AMTECH American Technical Laboratories, Inc.
8909 Complex Drive — Suite F San Diego, California 92123 (714) 560-7717

LABORATORY NO:	0622-78	
DATE OF REPORT:	September 1, 1978	
IDENTIFICATION:	OI-5 7-19	

GEOTHERMEX
901 MENDOCINO AVE.
BERKELEY, CA. 94707

SPECIES	mg/L	eq/L
Ca	97.	48-4
Mg	50.	41-4
Na	260.	11-3
K	16.	41-5
HCO_3	580.	95-4
CO_3		
CO_2(FREE)		
SO_4	310.	65-4
Cl	140.	39-4
TDS	1273.	
pH	8.02	
Ec μmhos/cm @25°	1890.	2037. (1:3
Ec μmhos/CALC		2218.
Ec OBS/CALC		.918
CATIONS Σ+		20700.
ANIONS Σ-		19900.

SPECIES	mg/L	eq/L
B	0.50	46-6 (a)
SiO_2	47.	78-5 (a)
NH_4		
F	0.98	52-6
S^{2-}		
Fe^{3+}		
Mn^{2+}		
Rb		
Li		
Sr		
Cs		
Ba		
Hg		

(a) MOLES/L

Analysis by:
AMTECH American Technical Laboratories, Inc.
8909 Complex Drive — Suite F San Diego, California 92123 (714) 560-7717

LABORATORY NO: 0622-78
DATE OF REPORT: September 1, 1978
IDENTIFICATION: OI-6 7-19

GEOTHERMEX
901 MENDOCINO AVE.
BERKELEY, CA. 94707

SPECIES	mg/L	eq/L
Ca	27.	13-4
Mg	8.0	66-5
Na	53.	23-4
K	10.	26-5
HCO_3	250.	41-4
CO_3		
CO_2(FREE)		
SO_4	<5.0	<10-5
Cl	13.	37-5
TDS	308.	
pH	7.93	
Ec μmhos/cm @25°	460.	
Ec μmhos/CALC	439.	
Ec OBS/CALC	1.049	
CATIONS Σ+		4520.
ANIONS Σ-		4460.

SPECIES	mg/L	eq/L
B	0.10	93-7 (a)
SiO_2	64.	11-4 (a)
NH_4		
F	0.66	35-6
S^{2-}		
Fe^{3+}		
Mn^{2+}		
Rb		
Li		
Sr		
Cs		
Ba		
Hg		

(a) MOLES/L

Analysis by:
AMTECH American Technical Laboratories, Inc.

8909 Complex Drive — Suite F San Diego, California 92123 (714) 560-7717

LABORATORY NO: 0622-78
DATE OF REPORT: September 1, 1978
IDENTIFICATION: OI-7 7-20

GEOTHERMEX
901 MENDOCINO AVE.
BERKELEY, CA. 94707

SPECIES	mg/L	eq/L
Ca	72.	36-4
Mg	28.	23-4
Na	63.	28-4
K	7.5	19-5
HCO_3	260.	43-4
CO_3		
CO_2(FREE)		
SO_4	150.	31-4
Cl	26.	73-5
TDS	526.	
pH	7.91	
Ec µmhos/cm @25°	794.	939.(1:10)
Ec µmhos/CALC		915.
Ec OBS/CALC		1.03
CATIONS Σ+		8830.
ANIONS Σ-		8120.

SPECIES	mg/L	eq/L
B	0.11	10-6 (a)
SiO_2	41.	68-5 (a)
NH_4		
F	0.88	46-6
S^{2-}		
Fe^{3+}		
Mn^{2+}		
Rb		
Li		
Sr		
Cs		
Ba		
Hg		

(a) MOLES/L

Analysis by:
AMTECH American Technical Laboratories, Inc.
8909 Complex Drive — Suite F San Diego, California 92123 (714) 560-7717

LABORATORY NO: 0622-78
DATE OF REPORT: September 1, 1978
IDENTIFICATION: OI-8 7-20

GEOTHERMEX
901 MENDOCINO AVE.
BERKELEY, CA. 94707

SPECIES	mg/L	eq/L
Ca	85.	42-4
Mg	45.	37-4
Na	150.	65-4
K	16.	41-5
HCO_3	480.	79-4
CO_3		
CO_2(FREE)		
SO_4	220.	46-4
Cl	59.	17-4
TDS	919.	
pH	8.00	
Ec µmhos/cm @25°	1360.	1446.(1:2)
Ec µmhos/CALC		1550.
Ec OBS/CALC		.933
CATIONS Σ+		14900.
ANIONS Σ-		14100.

SPECIES	mg/L	eq/L
B	0.36	33-6 (a)
SiO_2	56.	93-5 (a)
NH_4		
F	0.54	28-6
S^{2-}		
Fe^{3+}		
Mn^{2+}		
Rb		
Li		
Sr		
Cs		
Ba		
Hg		

(a) MOLES/L

Analysis by:
AMTECH American Technical Laboratories, Inc.
8909 Complex Drive — Suite F San Diego, California 92123 (714) 560-7717

LABORATORY NO: 0622-78
DATE OF REPORT: September 1, 1978
IDENTIFICATION: OI-9 7-20

GEOTHERMEX
901 MENDOCINO AVE.
BERKELEY, CA. 94707

SPECIES	mg/L	eq/L
Ca	64.	32-4
Mg	26.	21-4
Na	190.	83-4
K	18.	46-5
HCO_3	500.	82-4
CO_3		
CO_2(FREE)		
SO_4	190.	40-4
Cl	80.	23-4
TDS	905.	
pH	7.95	
Ec µmhos/cm @25°	1364.	1474.(1:2)
Ec µmhos/CALC		1525.
Ec OBS/CALC		.967
CATIONS Σ+		14100.
ANIONS Σ-		14400.

SPECIES	mg/L	eq/L
B	0.37	34-6 (a)
SiO_2	62.	10-4 (a)
NH_4		
F	0.37	19-6
S^{2-}		
Fe^{3+}		
Mn^{2+}		
Rb		
Li		
Sr		
Cs		
Ba		
Hg		

(a) MOLES/L

Analysis by:
AMTECH American Technical Laboratories, Inc.
8909 Complex Drive — Suite F San Diego, California 92123 (714) 560-7717

LABORATORY NO: 0622-78
DATE OF REPORT: September 1, 1978
IDENTIFICATION: OI-10 7-20

GEOTHERMEX
901 MENDOCINO AVE.
BERKELEY, CA. 94707

SPECIES	mg/L	eq/L
Ca	38.	19-4
Mg	27.	22-4
Na	120.	52-4
K	16.	41-5
HCO_3	440.	72-4
CO_3		
CO_2(FREE)		
SO_4	78.	16-4
Cl	34.	96-5
TDS	618.	
pH	7.91	
Ec µmhos/cm @25°	980.	
Ec µmhos/CALC	994.	
Ec OBS/CALC	0.985	
CATIONS Σ+		9750.
ANIONS Σ-		9800.

SPECIES	mg/L	eq/L
B	0.24	22-6 (a)
SiO_2	64.	11-4 (a)
NH_4		
F	0.58	31-6
S^{2-}		
Fe^{3+}		
Mn^{2+}		
Rb		
Li		
Sr		
Cs		
Ba		
Hg		

(a) MOLES/L

Analysis by:
AMTECH American Technical Laboratories, Inc.
8909 Complex Drive — Suite F San Diego, California 92123 (714) 560-7717

LABORATORY NO: 0622-78
DATE OF REPORT: September 1, 1978
IDENTIFICATION: OI-11 7-21

GEOTHERMEX
901 MENDOCINO AVE.
BERKELEY, CA. 94707

SPECIES	mg/L	eq/L
Ca	24.	12-4
Mg	7.1	58-5
Na	91.	40-4
K	7.0	18-5
HCO_3	150.	25-4
CO_3		
CO_2(FREE)		
SO_4	120.	25-4
Cl	35.	99-5
TDS	456.	
pH	7.93	
Ec µmhos/cm @25°	601.	
Ec µmhos/CALC	663.	
Ec OBS/CALC	0.906	
CATIONS Σ+		5920.
ANIONS Σ-		5950.

SPECIES	mg/L	eq/L
B	1.1	10-5 (a)
SiO_2	86.	14-4 (a)
NH_4		
F	2.2	12-5
S^{2-}		
Fe^{3+}		
Mn^{2+}		
Rb		
Li		
Sr		
Cs		
Ba		
Hg		

(a) MOLES/L

Analysis by:

AMTECH American Technical Laboratories, Inc.
8909 Complex Drive — Suite F San Diego, California 92123 (714) 560-7717

LABORATORY NO: 0622-78
DATE OF REPORT: September 1, 1978
IDENTIFICATION: OI-11A 7-21

GEOTHERMEX
901 MENDOCINO AVE.
BERKELEY, CA. 94707

SPECIES	mg/L	eq/L
Ca	2.5	12-5
Mg	0.1	82-7
Na	130.	57-4
K	6.9	18-5
HCO_3	82.	13-4
CO_3	5.7	19-5
CO_2(FREE)		
SO_4	160.	33-4
Cl	49.	14-4
TDS	536.	
pH	8.83	
Ec µmhos/cm @25°	673.	
Ec µmhos/CALC	722.	
Ec OBS/CALC	0.932	
CATIONS Σ+		5960.
ANIONS Σ-		6250.

SPECIES	mg/L	eq/L
B	2.2	20-5 (a)
SiO_2	130.	22-4 (a)
NH_4		
F	3.9	21-5
S^{2-}		
Fe^{3+}		
Mn^{2+}		
Rb		
Li		
Sr		
Cs		
Ba		
Hg		

(a) MOLES/L

Analysis by:
AMTECH American Technical Laboratories, Inc.
8909 Complex Drive — Suite F San Diego, California 92123 (714) 560-7717

LABORATORY NO:	0622-78	
DATE OF REPORT:	September 1, 1978	
IDENTIFICATION:	OI-12 7-21	

GEOTHERMEX
901 MENDOCINO AVE.
BERKELEY, CA. 94707

SPECIES	mg/L	eq/L
Ca	75.	37-4
Mg	30.	25-4
Na	170.	74-4
K	12.	31-5
HCO_3	500.	82-4
CO_3		
CO_2(FREE)		
SO_4	160.	33-4
Cl	41.	12-4
TDS	888.	
pH	7.80	
Ec μmhos/cm @25°	1345.	
Ec μmhos/CALC	1385.	
Ec OBS/CALC	0.971	
CATIONS Σ+		13900.
ANIONS Σ-		12700.

SPECIES	mg/L	eq/L
B	0.40	37-6 (a)
SiO_2	45.	75-5 (a)
NH_4		
F	0.98	52-6
S^{2-}		
Fe^{3+}		
Mn^{2+}		
Rb		
Li		
Sr		
Cs		
Ba		
Hg		

(a) MOLES/L

Analysis by:
AMTECH American Technical Laboratories, Inc.
8909 Complex Drive — Suite F San Diego, California 92123 (714) 560-7717

Amtech Laboratories
Lab #0622-78
Page 2

CONDUCTIVITY

Sample	Ec
Deionized Water (2,3,5,12)	4.57
Deionized Water (8,9)	1.75

CHLORIDE

Sample	mg/ℓ	eq/ℓ
Deionized Water (2,3,5,12)	<0.3	<85-7
Deionized Water (8,9)	<0.3	<85-7

GeothermEx, Inc. 901 MENDOCINO AVE.
BERKELEY, CA. 94707

JAMES B. KOENIG (415) 527-9876
MURRAY C. GARDNER

APPENDIX I

GEOPHYSICAL LOGS

Copies of the logs shown on the accompanying table are parts of this appendix. The logs are being sent to recipients of the report directly by Welex. No geophysical logs were run from the surface to 925 feet either before or after setting 13-3/8-inch casing. The only surveys which include the interval from 7,955 to 8,182 feet are the neutron and microseismogram logs run from 6,800 to 8,198 feet, after setting the 9-5/8-inch casing.

TABLE I-1

Geophysical Logs

Log Type	Date	Run	Interval	Scale	Comments
Dual Induction Guard Log	9/18/79	1	925- 7,150	1"=50'	
	10/1/79	2	7,150- 7,956	1"=50'	
	11/8/79	3	8,182-10,053	1"=50'	No log 7,956-8,182
	9/18/79	1	925- 7,150	1"=20'	
	10/1/79	2	7,150- 7,956	1"=20'	
	11/8/79	3	8,182-10,053	1"=20'	No log 7,956-8,182
Compensated Acoustic Velocity Log (with Gamma Ray and Caliper)	9/18/79	1	925- 7,148	1"=50'	
	10/1/79	2	7,148- 7,952	1"=50'	
	11/8/79	3	8,182-10,048	1"=50'	No log 7,952-8,182
	9/18/79	1	925- 7,148	1"=20'	
	10/1/79	2	7,148- 7,952	1"=20'	
	11/8/79	3	8,132-10,048	1"=20'	No log 7,952-8,182
Compensated Density Log (with Gamma Ray and Caliper)	9/19/79	1	925- 7,150	1"=50'	
	10/3/79	2	7,150- 7,955	1"=50'	
	11/8/79	3	8,182-10,053	1"=50'	No log 7,955-8,182
	9/18/79	1	925- 7,150	1"=20'	
	10/3/79	2	7,150- 7,955	1"=20'	
	11/8/79	3	8,132-10,053	1"=20'	No log 7,955-8,182
Fracture Finder-Microseismogram Log	9/18/79	1	925- 7,148	1"=20'	
	10/1/79	2	7,148- 7,952	1"=20'	
	11/8/79	3	8,180-10,047	1"=20'	No log 7,952-8,182
Neutron-Microseismogram Log--cased hole (with Collar Log)	11/9/79	1	6,800- 8,198	1"=20'	

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APPENDIX J

TEMPERATURE SURVEYS AND MAXIMUM READING THERMOMETER DATA

All of the temperature data collected during the drilling and logging of this well (table 1) are part of this appendix. The WELEX downhole survey records are sent directly by WELEX to recipients of the report. Summaries of the data are included herein.

Here's our graph

TABLE J-1. WELEX TEMPERATURE LOGS (CONTINUOUS RECORDING)

Run	Date	Hours After Last Circulation	Interval	Log Bottom Hole Temperature	Maximum-Reading Thermometers
1	9/18/79	8	0- 7,150	222°F	
2	9/19/79	24	0- 7,150	272°F	
3	9/19/79	39-1/4	0- 7,150	293°F	305°, 314°, 314°, 323°, 328°
4	9/20/79	50-3/4	0- 7,140	295°F	290°, 318°, 318°
5	10/ 1 /79	26-1/4	0- 7,958	267°F	286°, 300°
6	10/ 2 /79	39-1/4	0- 7,958	270°F	316°, 318°, 332°
7	10/ 2 /79	44-1/4	6,000- 7,958	283°F	288°, 304°, 308°
8	11/ 9 /79	29	0-10,053	336°F	317°, 317°
9	11/10/79	50	0- 9,400±	Unknown, tool stopped at 9,350' at a T of 320°	320°, 350° (at 9,300±)

TABLE J-1, CONTINUED

LOCATION: WELEX LOG
18S/47E- 3
HOLE NAME: ORE-IDA
DATE MEASURED: 9/18/79

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
30.5	100.0	58.330	136.99	0.0	0.0
152.4	500.0	70.830	159.49	102.5	5.6
304.9	1000.0	73.060	163.51	14.6	0.8
457.3	1500.0	74.170	165.51	7.3	0.4
609.8	2000.0	76.110	169.00	12.7	0.7
762.2	2500.0	76.670	170.01	3.7	0.2
914.6	3000.0	79.720	175.50	20.0	1.1
1067.1	3500.0	82.220	180.00	16.4	0.9
1219.5	4000.0	80.560	177.01	-10.9	-0.6
1371.9	4500.0	84.720	184.50	27.3	1.5
1524.4	5000.0	87.220	189.00	16.4	0.9
1676.8	5500.0	89.440	192.99	14.6	0.8
1829.3	6000.0	91.670	197.01	14.6	0.8
1981.7	6500.0	93.610	200.50	12.7	0.7
2012.2	6600.0	92.500	198.50	-36.4	-2.0
2042.7	6700.1	93.330	199.99	27.2	1.5
2073.2	6800.0	93.330	199.99	0.0	0.0
2103.7	6900.0	94.440	201.99	36.4	2.0
2134.1	7000.0	96.670	206.01	73.1	4.0
2164.6	7100.0	97.500	207.50	27.2	1.5
2179.9	7150.0	105.000	221.00	491.8	27.0

TABLE J-1, CONTINUED

LOCATION: WELEX LOG
18S/47E- 3
HOLE NAME: ORE-IDA
DATE MEASURED: 9/19/79

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
30.5	100.0	55.000	131.00	0.0	0.0
152.4	500.0	65.830	150.49	88.8	4.9
304.9	1000.0	70.000	158.00	27.4	1.5
457.3	1500.0	72.780	163.00	18.2	1.0
609.8	2000.0	76.110	169.00	21.8	1.2
731.7	2400.0	76.670	170.01	4.6	0.3
762.2	2500.0	77.780	172.00	36.4	2.0
914.6	3000.0	83.890	183.00	40.1	2.2
1067.1	3500.0	87.780	190.00	25.5	1.4
1219.5	4000.0	90.000	194.00	14.6	0.8
1371.9	4500.0	94.440	201.99	29.1	1.6
1524.4	5000.0	97.500	207.50	20.1	1.1
1676.8	5500.0	102.220	216.00	31.0	1.7
1829.3	6000.0	106.390	223.50	27.4	1.5
1859.8	6100.0	105.280	221.50	-36.4	-2.0
1890.2	6200.0	105.560	222.01	9.2	0.5
1920.7	6300.0	107.780	226.00	72.8	4.0
1951.2	6400.0	110.560	231.01	91.2	5.0
1981.7	6500.0	112.780	235.00	72.8	4.0
2012.2	6600.0	114.440	237.99	54.4	3.0
2042.7	6700.0	116.110	241.00	54.8	3.0
2073.2	6800.0	117.220	243.00	36.4	2.0
2103.7	6900.0	120.560	249.01	109.5	6.0
2134.1	7000.0	121.940	251.49	45.3	2.5
2164.6	7100.0	127.220	261.00	173.2	9.5
2179.9	7150.0	130.280	266.50	200.7	11.0

TABLE J-1, CONTINUED

LOCATION: WELEX LOG
18S/47E- 3
HOLE NAME: ORE-IDA
DATE MEASURED: 9/19/79

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
30.5	100.0	48.890	120.00	0.0	0.0
152.4	500.0	59.440	138.99	86.5	4.7
304.9	1000.0	64.170	147.51	31.0	1.7
457.3	1500.0	68.610	155.50	29.1	1.6
609.8	2000.0	74.170	165.51	36.5	2.0
762.2	2500.0	78.330	172.99	27.3	1.5
914.6	3000.0	83.610	182.50	34.6	1.9
1067.1	3500.0	89.170	192.51	36.5	2.0
1219.5	4000.0	93.060	199.51	25.5	1.4
1371.9	4500.0	97.780	208.00	31.0	1.7
1524.4	5000.0	102.780	217.00	32.8	1.8
1676.8	5500.0	108.890	228.00	40.1	2.2
1829.3	6000.0	113.890	237.00	32.8	1.8
1859.8	6100.0	112.780	235.00	-36.4	-2.0
1890.2	6200.0	113.330	235.99	18.0	1.0
1920.7	6300.0	116.110	241.00	91.2	5.0
1951.2	6400.0	119.440	246.99	109.2	6.0
1981.7	6500.0	122.220	252.00	91.2	5.0
2012.2	6600.0	125.000	257.00	91.2	5.0
2042.7	6700.0	127.220	261.00	72.8	4.0
2073.2	6800.0	129.170	264.51	64.0	3.5
2103.7	6900.0	132.780	271.00	118.4	6.5
2134.1	7000.0	135.000	275.00	72.8	4.0
2164.6	7100.0	140.560	285.01	182.4	10.0
2179.9	7150.0	145.000	293.00	291.1	16.0

TABLE J-1, CONTINUED

LOCATION: WELEX LOG
18S/47E- 3
HOLE NAME: ORE-IDA
DATE MEASURED: 9/20/79

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
30.5	100.0	49.439	120.99	0.0	0.0
152.4	500.0	60.000	140.00	86.6	4.8
304.9	1000.0	64.439	147.99	29.1	1.6
457.3	1500.0	68.611	155.50	27.4	1.5
609.8	2000.0	73.889	165.00	34.6	1.9
762.2	2500.0	78.889	174.00	32.8	1.8
914.6	3000.0	84.439	183.99	36.4	2.0
1067.1	3500.0	89.439	192.99	32.8	1.8
1219.5	4000.0	94.172	201.51	31.1	1.7
1372.0	4500.0	99.172	210.51	32.8	1.8
1524.4	5000.0	103.328	217.99	27.3	1.5
1676.8	5500.0	110.000	230.00	43.8	2.4
1829.3	6000.0	114.722	238.50	31.0	1.7
1859.8	6100.0	113.889	237.00	-27.3	-1.5
1890.2	6200.0	115.000	239.00	36.4	2.0
1920.7	6300.0	118.328	244.99	109.2	6.0
1951.2	6400.0	121.111	250.00	91.3	5.0
1981.7	6500.0	123.328	253.99	72.7	4.0
2012.2	6600.0	126.672	260.01	109.7	6.0
2042.7	6700.0	128.889	264.00	72.7	4.0
2073.2	6800.0	131.111	268.00	72.9	4.0
2103.7	6900.0	134.722	274.50	118.4	6.5
2134.1	7000.0	136.672	278.01	64.0	3.5
2164.6	7100.0	141.111	286.00	145.6	8.0
2179.9	7150.0	146.389	295.50	346.2	19.0

TABLE J-1, CONTINUED

LOCATION: WELEX LOG
18S/47E- 3
HOLE NAME: ORE-IDA
DATE MEASURED: 10/ 1/79

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT.
30.5	100.0	37.780	100.00	0.0	0.0
152.4	500.0	56.670	134.01	154.9	8.5
304.9	1000.0	61.110	142.00	29.1	1.6
457.3	1500.0	64.440	147.99	21.8	1.2
609.8	2000.0	68.890	156.00	29.2	1.6
762.2	2500.0	72.780	163.00	25.5	1.4
914.6	3000.0	77.220	171.00	29.1	1.6
1067.1	3500.0	81.110	178.00	25.5	1.4
1219.5	4000.0	85.000	185.00	25.5	1.4
1371.9	4500.0	88.890	192.00	25.5	1.4
1524.4	5000.0	91.670	197.01	18.2	1.0
1676.8	5500.0	96.110	205.00	29.1	1.6
1829.3	6000.0	100.000	212.00	25.5	1.4
1859.8	6100.0	98.330	208.99	-54.8	-3.0
1890.2	6200.0	99.170	210.51	27.6	1.5
1920.7	6300.0	101.390	214.50	72.8	4.0
1951.2	6400.0	103.330	217.99	63.6	3.5
1981.7	6500.0	105.000	221.00	54.8	3.0
2012.2	6600.0	106.110	223.00	36.4	2.0
2042.7	6700.0	106.670	224.01	18.4	1.0
2073.2	6800.0	106.670	224.01	0.0	0.0
2103.7	6900.0	106.670	224.01	0.0	0.0
2134.1	7000.0	105.560	222.01	-36.4	-2.0
2164.6	7100.0	103.330	217.99	-73.2	-4.0
2195.1	7200.0	107.220	225.00	127.6	7.0
2225.6	7300.0	111.940	233.49	154.8	8.5
2256.1	7400.0	113.610	236.50	54.8	3.0
2286.6	7500.0	113.890	237.00	9.2	0.5
2317.1	7600.0	117.220	243.00	109.3	6.0
2347.6	7700.0	120.000	248.00	91.2	5.0
2378.1	7800.0	122.780	253.00	91.2	5.0
2408.5	7900.0	123.330	253.99	18.0	1.0
2423.8	7950.0	126.110	259.00	182.4	10.0
2426.8	7960.0	130.560	267.01	1459.0	80.0

TABLE J-1, CONTINUED

LOCATION: WELEX LOG
18S/47E- 3
HOLE NAME: ORE-IDA
DATE MEASURED: 10/ 2/79

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
30.5	100.0	35.000	95.00	0.0	0.0
152.4	500.0	53.890	129.00	154.9	8.5
304.9	1000.0	58.890	138.00	32.8	1.8
457.3	1500.0	62.780	145.00	25.5	1.4
609.8	2000.0	65.560	150.01	18.2	1.0
762.2	2500.0	70.560	159.01	32.8	1.8
914.6	3000.0	76.110	169.00	36.4	2.0
1067.1	3500.0	80.560	177.01	29.2	1.6
1219.5	4000.0	84.440	183.99	25.5	1.4
1371.9	4500.0	89.440	192.99	32.8	1.8
1524.4	5000.0	93.890	201.00	29.2	1.6
1676.8	5500.0	98.330	208.99	29.1	1.6
1829.3	6000.0	102.780	217.00	29.2	1.6
1981.7	6500.0	105.830	222.49	20.0	1.1
2134.1	7000.0	110.000	230.00	27.4	1.5
2164.6	7100.0	111.110	232.00	36.4	2.0
2195.1	7200.0	109.440	228.99	-54.8	-3.0
2225.6	7300.0	111.670	233.01	73.1	4.0
2256.1	7400.0	115.000	239.00	109.2	6.0
2286.6	7500.0	117.220	243.00	72.8	4.0
2317.1	7600.0	119.440	246.99	72.8	4.0
2347.6	7700.0	121.670	251.01	73.1	4.0
2378.1	7800.0	123.890	255.00	72.8	4.0
2408.5	7900.0	126.670	260.01	91.2	5.0
2423.8	7950.0	127.220	261.00	36.1	2.0

TABLE J-1, CONTINUED

LOCATION: WELEX LOG
18S/47E- 3
HOLE NAME: ORE-IDA
DATE MEASURED: 10/ 2/79

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
1829.3	6000.0	103.330	217.99	0.0	0.0
1859.8	6100.0	103.890	219.00	18.4	1.0
1890.2	6200.0	103.330	217.99	-18.4	-1.0
1920.7	6300.0	103.610	218.50	9.2	0.5
1951.2	6400.0	105.830	222.49	72.8	4.0
1981.7	6500.0	107.780	226.00	64.0	3.5
2012.2	6600.0	109.440	228.99	54.4	3.0
2042.7	6700.0	111.110	232.00	54.8	3.0
2073.2	6800.0	111.940	233.49	27.2	1.5
2103.7	6900.0	112.220	234.00	9.2	0.5
2134.1	7000.0	112.220	234.00	0.0	0.0
2164.6	7100.0	111.390	232.50	-27.2	-1.5
2195.1	7200.0	110.560	231.01	-27.2	-1.5
2225.6	7300.0	115.000	239.00	145.6	8.0
2256.1	7400.0	118.890	246.00	127.6	7.0
2286.6	7500.0	120.830	249.49	63.6	3.5
2317.1	7600.0	122.780	253.00	64.0	3.5
2347.6	7700.0	125.000	257.00	72.8	4.0
2378.1	7800.0	128.890	264.00	127.6	7.0
2408.5	7900.0	130.830	267.49	63.6	3.5

TABLE J-1, CONTINUED

LOCATION: WELEX LOG
18S/47E- 3
HOLE NAME: ORE-IDA
DATE MEASURED: 11/ 9/79

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
30.5	100.0	41.940	107.49	0.0	0.0
152.4	500.0	57.280	135.10	125.8	6.9
304.9	1000.0	64.890	148.80	49.9	2.7
457.3	1500.0	70.500	158.90	36.8	2.0
609.8	2000.0	76.390	169.50	38.6	2.1
762.2	2500.0	82.220	180.00	38.2	2.1
914.6	3000.0	88.060	190.51	38.3	2.1
1067.1	3500.0	94.440	201.99	41.9	2.3
1219.5	4000.0	99.170	210.51	31.0	1.7
1371.9	4500.0	104.720	220.50	36.4	2.0
1524.4	5000.0	109.440	228.99	31.0	1.7
1676.8	5500.0	114.440	237.99	32.8	1.8
1829.3	6000.0	118.890	246.00	29.2	1.6
1981.7	6500.0	120.560	249.01	11.0	0.6
2134.1	7000.0	128.330	262.99	51.0	2.8
2286.6	7500.0	133.610	272.50	34.6	1.9
2439.0	8000.0	140.000	284.00	41.9	2.3
2469.5	8100.0	139.720	283.50	-9.2	-0.5
2484.8	8150.0	138.170	280.71	-101.6	-5.6
2500.0	8200.0	131.110	268.00	-463.3	-25.4
2515.2	8250.0	135.560	276.01	292.0	16.0
2530.5	8300.0	135.280	275.50	-18.4	-1.0
2561.0	8400.0	136.670	278.01	45.6	2.5
2576.2	8450.0	138.890	282.00	145.7	8.0
2591.5	8500.0	132.220	270.00	-437.7	-24.0
2606.7	8550.0	140.670	285.21	554.1	30.4
2621.9	8600.0	139.720	283.50	-62.3	-3.4
2637.2	8650.0	138.890	282.00	-54.4	-3.0
2652.4	8700.0	140.830	285.49	127.3	7.0
2667.7	8750.0	137.780	280.00	-200.1	-11.0
2682.9	8800.0	133.610	272.50	-273.4	-15.0
2698.2	8850.0	143.330	289.99	637.8	35.0
2713.4	8900.0	145.000	293.00	109.6	6.0
2728.7	8950.0	143.610	290.50	-91.1	-5.0
2743.9	9000.0	143.330	289.99	-18.4	-1.0
2759.1	9050.0	141.940	287.49	-91.1	-5.0
2774.4	9100.0	143.280	289.90	87.9	4.8
2789.6	9150.0	142.560	288.61	-47.2	-2.6
2804.9	9200.0	141.670	287.01	-58.4	-3.2
2820.1	9250.0	147.220	297.00	364.2	20.0
2835.4	9300.0	150.560	303.01	219.0	12.0

TABLE J-1, CONTINUED

LOCATION: WELEX LOG
18S/47E- 3
HOLE NAME: ORE-IDA
DATE MEASURED: 11/ 9/79

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
2850.6	9350.0	151.110	304.00	36.1	2.0
2865.9	9400.0	154.170	309.51	200.8	11.0
2881.1	9450.0	155.560	312.01	91.1	5.0
2896.3	9500.0	156.670	314.01	72.8	4.0
2911.6	9550.0	157.220	315.00	36.1	2.0
2926.8	9600.0	157.780	316.00	36.7	2.0
2942.1	9650.0	158.610	317.50	54.5	3.0
2957.3	9700.0	161.670	323.01	200.7	11.0
2972.6	9750.0	165.560	330.01	255.2	14.0
2987.8	9800.0	166.670	332.01	72.8	4.0
3003.1	9850.0	165.280	329.50	-91.2	-5.0
3018.3	9900.0	165.560	330.01	18.4	1.0
3033.5	9950.0	166.670	332.01	72.8	4.0
3048.8	*10000	167.780	334.00	72.8	4.0
3064.0	*10050	168.330	334.99	36.1	2.0

TABLE J-1, CONTINUED

LOCATION: WELEX LOG
18S/47E- 3
HOLE NAME: ORE-IDA
DATE MEASURED: 11/ 9/79

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	DEG F	GEOTHERMAL GRADIENT DEG C/KM	DEG F/100 FT
15.2	50.0	27.220	81.00	0.0	0.0
30.5	100.0	33.330	91.99	400.7	22.0
152.4	500.0	48.890	120.00	127.6	7.0
304.9	1000.0	57.220	135.00	54.6	3.0
457.3	1500.0	63.330	145.99	40.1	2.2
609.8	2000.0	70.170	158.31	44.9	2.5
762.2	2500.0	77.220	171.00	46.2	2.5
914.6	3000.0	86.110	187.00	58.3	3.2
1067.1	3500.0	92.780	199.00	43.8	2.4
1219.5	4000.0	98.890	210.00	40.1	2.2
1371.9	4500.0	105.000	221.00	40.1	2.2
1524.4	5000.0	110.560	231.01	36.5	2.0
1676.8	5500.0	116.110	241.00	36.4	2.0
1829.3	6000.0	121.940	251.49	38.2	2.1
1981.7	6500.0	128.330	262.99	41.9	2.3
2134.1	7000.0	133.330	271.99	32.8	1.8
2286.6	7500.0	138.610	281.50	34.6	1.9
2317.1	7600.0	140.000	284.00	45.6	2.5
2347.6	7700.0	140.830	285.49	27.2	1.5
2378.1	7800.0	141.670	287.01	27.5	1.5
2396.3	7860.0	140.280	284.50	-76.0	-4.2
2408.5	7900.0	141.110	286.00	68.0	3.7
2423.8	7950.0	144.720	292.50	236.9	13.0
2439.0	8000.0	145.830	294.49	72.8	4.0
2469.5	8100.0	146.390	295.50	18.4	1.0
2484.8	8150.0	146.110	295.00	-18.4	-1.0
2500.0	8200.0	140.000	284.00	-400.9	-22.0
2503.1	8210.0	138.330	280.99	-547.5	-30.0
2530.5	8300.0	143.720	290.70	196.4	10.8
2539.6	8330.0	142.220	288.00	-164.1	-9.0
2553.4	8375.0	129.440	264.99	-931.5	-51.1
2561.0	8400.0	140.280	284.50	1420.7	78.0
2576.2	8450.0	148.890	300.00	565.0	31.0
2591.5	8500.0	144.440	291.99	-292.0	-16.0
2597.6	8520.0	141.390	286.50	-500.0	-27.4
2606.7	8550.0	149.720	301.50	910.4	50.0
2621.9	8600.0	148.890	300.00	-54.5	-3.0
2637.2	8650.0	148.890	300.00	0.0	0.0
2652.4	8700.0	149.170	300.51	18.4	1.0
2667.7	8750.0	147.780	298.00	-91.2	-5.0
2682.9	8800.0	147.780	298.00	0.0	0.0

TABLE J-1, CONTINUED

LOCATION: WELEX LOG
18S/47E- 3
HOLE NAME: ORE-IDA
DATE MEASURED: 11/ 9/79

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
2698.2	8850.0	148.330	298.99	36.1	2.0
2713.4	8900.0	153.610	308.50	346.5	19.0
2728.7	8950.0	154.720	310.50	72.8	4.0
2743.9	9000.0	155.000	311.00	18.4	1.0
2774.4	9100.0	154.720	310.50	-9.2	-0.5
2789.6	9150.0	153.890	309.00	-54.5	-3.0
2804.9	9200.0	151.390	304.50	-163.9	-9.0
2814.0	9230.0	154.440	309.99	333.7	18.3
2820.1	9250.0	154.170	309.51	-44.3	-2.4
2835.4	9300.0	153.890	309.00	-18.4	-1.0
2850.6	9350.0	155.560	312.01	109.6	6.0
2853.7	9360.0	155.280	311.50	-91.8	-5.0

TABLE J-1, CONTINUED

LOCATION: BAKER AMS, OREGON
18S/47E- 4DC
HOLE NAME: ONTCTYPK.
DATE MEASURED: 8/19/77

DEPTH METERS	DEPTH FEET	TEMPERATURE DEG C	TEMPERATURE DEG F	GEOTHERMAL GRADIENT DEG C/KM	GEOTHERMAL GRADIENT DEG F/100 FT
20.0	65.6	14.340	57.81	0.0	0.0
40.0	131.2	15.470	59.85	56.5	3.1
60.0	196.8	17.020	62.64	77.5	4.3
80.0	262.4	18.750	65.75	86.5	4.7
100.0	328.0	20.480	68.86	86.5	4.7
120.0	393.6	22.260	72.07	89.0	4.9
140.0	459.2	24.090	75.36	91.5	5.0
150.0	492.0	24.950	76.91	86.0	4.7

TABLE J-2. PRESSURE SERVICE

a. Wireline Survey

Date	Time	Run	Log Interval (feet)	Station Interval (feet)	Time on Bottom (minutes)
11/15/79	6:56 P.M.	1	7,000-10,000	200	30
11/15/79	9:58 P.M.	2	7,000-10,000	200	30
11/16/79	12:58 A.M.	3	7,000-10,000	200	30
11/17/79	?	?	7,000- 9,870	200	30
11/24/79	2:30 A.M.	-	6,000- 9,960	Variable	6

b. Temperature Buildup on Bottom

Date	Period	Time on Bottom (10,054 feet) (hours)
11/16/79	1:00 A.M. - 5:00 A.M.	4
11/17/79	12:26 A.M. - 4:30 A.M.	4
11/18/79	10:30 P.M. - 2:30 A.M.	4
11/18/79	5:00 A.M. - 9:00 A.M.	4
11/25/79	8:50 P.M. - 12:50 A.M.	4

PRESSURE SERVICE

P.O. BOX 624

ELK GROVE, CALIFORNIA, 95624

A Line of Service

SUB-SURFACE SURVEY

OWNER ORE-IDA FOODS INC. FIELD WELL NAME ORE-IDA #1

CASING 9-5/8" with shoe 8183' ELEV. DATE: 11-15-79

LINER DESCRIPTION 7" 32# N-80 & C-95 hung 8142-10,038' ZERO POINT 22.5'

Liner perforated with shop cut slots 2" X 1/8" 16 slots to foot. Depth 10,054'

TUBING DETAIL Drill pipe as needed @ ZONE

PUMP SHOE GAS ANCHOR INTAKE

PURPOSE Run three temperature surveys evenly spaced to get temperature build up data.

REMARKS 1st temperature survey was with 325° to 550° and temperature never came within range of instrument. Survey complete loss. This was followed by three surveys as below.

ELEMENT 125 - 350° F SERIAL No. 36394 CLOCK 3 hour 15 TURN screw

ENGAGE STYLUS DISENGAGE STYLUS

OBS TBG. PRESS. OBS. CSG. PRESS

COR. TBG. PRESS. COR. CSG. PRESS

PICKUP @ TIME ON BOTTOM TIME OFF BOTTOM

DEPTH	1st TEMPERATURE		2nd TEMPERATURE		3rd TEMPERATURE	
7000	252.1	6:56PM	251.8	9:58PM	253.8	12:58 Mid night
7200	256.4		256.0		258.6	
7400	260.7		260.6		262.4	
7600	264.2		264.8		266.6	
7800	266.6		267.8		269.4	
8000	272.5		273.8		275.5	
8200	273.8		276.0		277.8	
8400	271.5		275.1		276.8	
8600	280.4		283.2		285.0	
8800	283.0		285.8		287.9	
9000	288.3		289.9		293.0	
9200	291.5		293.9		296.2	
9400	301.3		303.6		305.8	
9600	304.3		306.7		309.1	
9800	312.4		315.0		317.4	
10,000	316.2		318.7		320.9	30 minutes on bottom
10,000	318.2		319.8		322.5	
	8:24 to 8:54		11:24 to 11:54		2:55 to 3:25	

R. K. McAnally

PRESSURE SERVICE

P.O. BOX 624
ELK GROVE, CALIFORNIA, 95624

A Line of Service

SUB-SURFACE SURVEY

OWNER ORE-IDA FOODS INC. FIELD WELL NAME ORE-IDA #1
CASING 9-5/8" with shoe 8183' ELEV. DATE: 11-16-79
LINER DESCRIPTION 7" Liner 32# N-80 & C-95 hung @ 8142 to 10,038' ZERO POINT 22.5'
Liner Perforated with shop cut slots 2" X 1.8" 16 slots per foot Depth 10,054
TUBING DETAIL @ ZONE

PUMP SHOE GAS ANCHOR INTAKE
PURPOSE Determine temperature and pressure build up over 4 hour period.
REMARKS Instrument #36394 and 20561

ELEMENT SERIAL No. CLOCK TURN
ENGAGE STYLUS DISENGAGE STYLUS
OBS TBG. PRESS. OBS. CSG. PRESS
COR. TBG. PRESS. COR. CSG. PRESS
PICKUP @ 9970' TIME ON BOTTOM 1:AM TIME OFF BOTTOM 5:AM

TIME	PRESSURE	TEMPERATURE
0	1667	325.8
2 hr	1674	327.2
4 hr	1681	328.5

R. K. McAnally

PRESSURE SERVICE

P.O. BOX 624
ELK GROVE, CALIFORNIA, 95624

A Line of Service

SUB-SURFACE SURVEY

OWNER ORE-IDA FOODS INC. FIELD WELL NAME ORE-IDA #1
CASING 9-5/8" with shoe 8183' ELEV. DATE: 11-16-79 11-17-79
LINER DESCRIPTION 7" Liner 32# N-80 and C-95 hung 8142-10,038' ZERO POINT 22.5'
Liner perforsted with shop cut slots 2" X 1/8" 16 slots per food Depth 10,054 TD
TUBING DETAIL @ ZONE

PUMP SHOE GAS ANCHOR INTAKE
PURPOSE Tandem instruments hung on bottom to determine fluid and temperature build up 4 hours.
REMARKS Instrument Serial #42317 and 36394

ELEMENT SERIAL No. CLOCK TURN
ENGAGE STYLUS DISENGAGE STYLUS
OBS TBG. PRESS. OBS. CSG. PRESS
COR. TBG. PRESS. COR. CSG. PRESS
PICKUP @ TIME ON BOTTOM 12:26AM TIME OFF BOTTOM 4:30AM 11-17-79

TIME	PRESSURE	TEMPERATURE
0 hr	153	327.1
1 hr	164	328.0
2 hr	175	329.5
3 hr	182	330.2
4 hr	197	331.0

R. K. McAnally

PRESSURE SERVICE

P.O. BOX 624

ELK GROVE, CALIFORNIA, 95624

A Line of Service

SUB-SURFACE SURVEY

OWNER ORE-IDA FOODS INC. FIELD WELL NAME ORE-IDA # 1

CASING 9-5/8" with shoe 8183 ELEV. DATE: 11-17-79

LINER DESCRIPTION 7" 32# N-80 & C-95 hung 8142 to 10,038' ZERO POINT 22.5'

Liner perforated with shop cut slots 2" X 1/8" 16 per foot. Depth 10,054 TD

TUBING DETAIL @ ZONE

PUMP SHOE GAS ANCHOR INTAKE

PURPOSE Tandem run with temp and pressure instruments to give build up profile of temp and press

REMARKS Instruments # 42317 and 36394 7000' to 9870' 5minute stop every 200' with 30 minutes on bottom

ELEMENT SERIAL No. CLOCK TURN

ENGAGE STYLUS DISENGAGE STYLUS

OBS TBG. PRESS. OBS. CSG. PRESS

COR. TBG. PRESS. COR. CSG. PRESS

PICKUP @ 9870' TIME ON BOTTOM 9:00AM TIME OFF BOTTOM 9:30AM 11-17-79

DEPTH	PRESSURE	TEMPERATURE	
7000	17	235.0	
7200	17	237.5	
7400	19	238.1	
7600	19	238.4	
7800	19	238.8	
8000	21	238.8	
8200	24	245.4	
8400	24	246.2	
8600	24	247.3	
8800	27	247.8	
9000	27	248.0	
9200	27	248.0	
9400	35	256.5	
9600	114	300.0	
9800	190	319.6	
9870	235	329.0	9:AM to 9:30AM 11-17-79
9870	238	332.1	

R. K. McAnally

PRESSURE SERVICE

P.O. BOX 624

ELK GROVE, CALIFORNIA, 95624

A Line of Service

SUB-SURFACE SURVEY

OWNER ORE-IDA FOODS INC.	FIELD	WELL NAME ORE-IDA # 1
CASING 9-5/8" with shoe @ 8183'	ELEV.	DATE: 11-18-79
LINER DESCRIPTION 7" 32# N-80 & C-95 hung 8142 to 10,038'		ZERO POINT 22.5'
Liner Perforated with shop cut slots 2" X 1/8" 16 per foot		Depth 10,054' TD
TUBING DETAIL	@	ZONE
PUMP SHOE	GAS ANCHOR	INTAKE
PURPOSE Determine pressure and temperature build up and rate.		
REMARKS Instrumant # 42317 and 36394.		
ELEMENT	SERIAL No.	CLOCK 24 hr 15 TURN
ENGAGE STYLUS	DISENGAGE STYLUS	
OBS. TBG. PRESS.	OBS. CSG. PRESS	
COR. TBG. PRESS.	COR. CSG. PRESS	
PICKUP @ 9900'	TIME ON BOTTOM 10:30PM	TIME OFF BOTTOM 2:30AM 11-19-79

TIME	PRESSURE	TEMPERATURE
0 hr	60	300.3
1 hr	81	299.3
2 hr	101	302.7
3 hr	115	306.6
4 hr	118	309.5

R. K. McAnally

PRESSURE SERVICE

P.O. BOX 624
ELK GROVE, CALIFORNIA, 95624

A Line of Service

SUB-SURFACE SURVEY

OWNER ORE-IDA FOODS INC. FIELD WELL NAME ORE-IDA # 1

CASING 9-5/8" with shoe @ 8183' ELEV. DATE: 11-18-79

LINER DESCRIPTION 7" 32# N-80 & C-95 hung 8142 to 10,038' ZERO POINT 22.5'

Liner Perforated with shop cut slots 2" X 1/8" 16 per foot Depth 10,054' TD

TUBING DETAIL @ ZONE

PUMP SHOE GAS ANCHOR INTAKE

PURPOSE Determine pressure and temperature build up and rate.

REMARKS Instrumant # 42317 and 36394.

ELEMENT SERIAL No. CLOCK 24 hr 15 TURN

ENGAGE STYLUS DISENGAGE STYLUS

OBS TBG. PRESS. OBS. CSG. PRESS

COR. TBG. PRESS. COR. CSG. PRESS

PICKUP @ 9900' TIME ON BOTTOM 10:30PM TIME OFF BOTTOM 2:30AM 11-19-79

TIME	PRESSURE	TEMPERATURE
0 hr	60	300.3
1 hr	81	299.3
2 hr	101	302.7
3 hr	115	306.6
4 hr	118	309.5

R. K. McAnally

TABLE J-2, CONTINUED

PRESSURE SERVICE

P.O. BOX 624

ELK GROVE, CALIFORNIA, 95624

A Line of Service

SUB-SURFACE SURVEY

OWNER ORE-IDA FOODS INC. FIELD WELL NAME ORE-IDA # 1

CASING 9-5/8" with shoe 8183' ELEV. DATE: 11-18-79

LINER DESCRIPTION 7 " 32 # N-80 & C-95 hung 8142 to 10,038' ZERO POINT 22.5'

Depth 10,054' TD.

TUBING DETAIL @ ZONE

PUMP SHOE GAS ANCHOR INTAKE

PURPOSE Determine fluid entry and temperature build up 4 hour period.

REMARKS Survey run and In and out pressure run to confirm pressure accurcy.

Instrument # 42317 and 36394

ELEMENT SERIAL No. CLOCK TURN

ENGAGE STYLUS DISENGAGE STYLUS

OBS TBG. PRESS. OBS. CSG. PRESS

COR. TBG. PRESS. COR. CSG. PRESS

PICKUP @ 9820' TIME ON BOTTOM 5AM TIME OFF BOTTOM 9AM

TIME	PRESSURE	TEMPERATURE
0 hr	670	332.0
1 hr		333.3
2 hr		333.6
3 hr		333.9
4 hr	666	334.0

R. K. McAnally

TABLE J-2, CONTINUED

PRESSURE SERVICE

P.O. BOX 624

ELK GROVE, CALIFORNIA, 95624

A Line of Service

SUBSURFACE PRESSURE SURVEY

OWNER ORE-IDA FOODS INC. FIELD WELL NAME ORE-IDA # 1

CASING 9-5/8" with shoe @ 8183' ELEV. DATE: 11-24-79

LINER DESCRIPTION 7" liner 32# N-80 & C-95 hung 8142-10,038' ZERO POINT 22.5'

Liner perforated with shop cut slots 2" X 1/8" 16 slots per foot Depth 10,054'

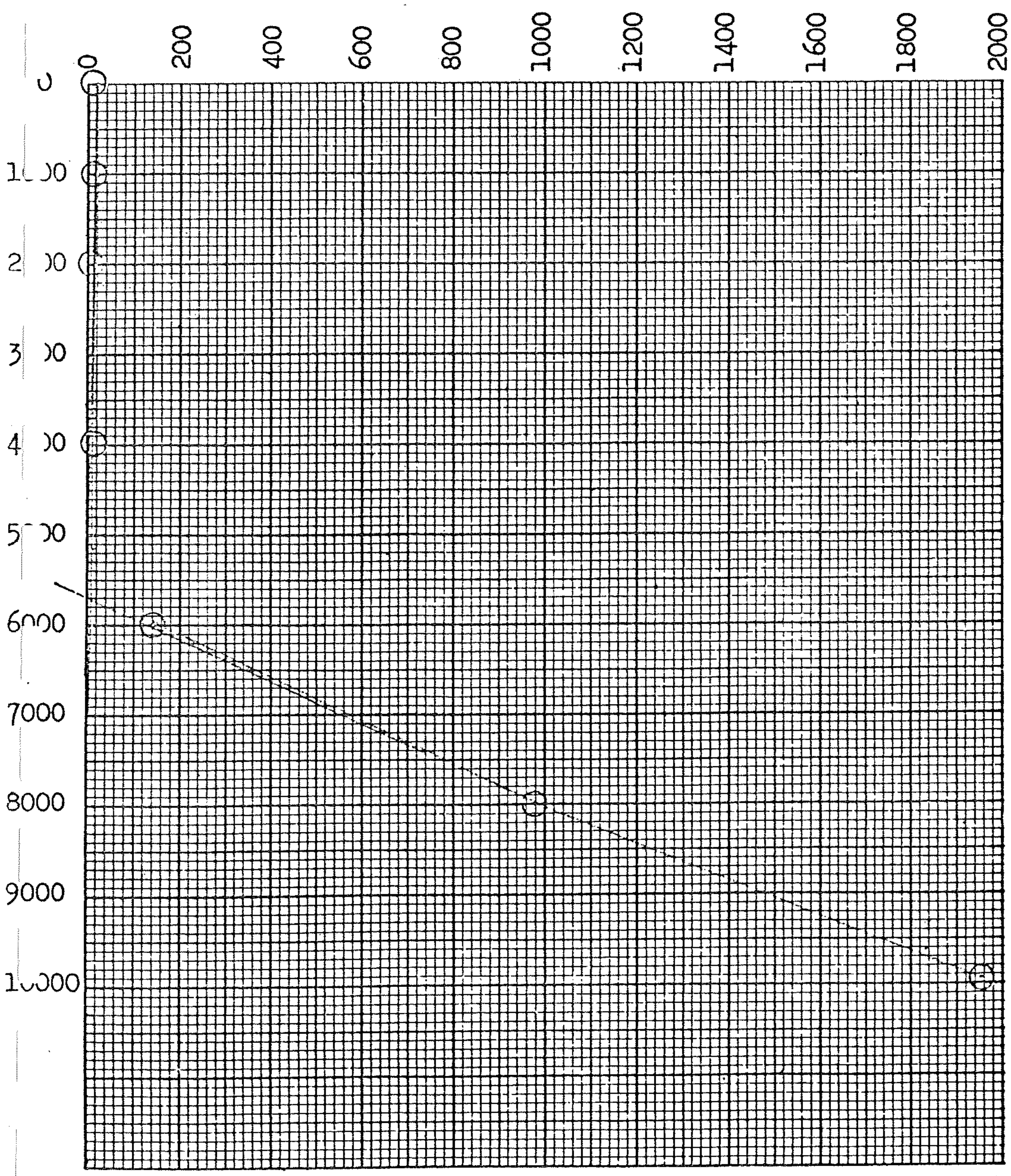
TUBING DETAIL @ ZONE

PUMP SHOE GAS ANCHOR INTAKE

PURPOSE to determine fluid level prior to making traverse from fluid to 9960'

REMARKS Instrument # 20561 with 3 hour clock.

PICKUP @ MAXIMUM TEMPERATURE 354 °F @ 9960 per maximum reading thermeter.



STABILIZATION PERIOD

GROSS OIL RATE B/D

NET OIL RATE B/D

FORMATION GAS MCF/D

GOR CFT/BBL.

CIRCULATED GAS MCF/D

OIL DRY GRAVITY °API

BEAN SIZE

CASING PRESSURE

TUBING PRESSURE

DEPTH	PRESSURE	GRADIENT
0	14	.---
2000	16	.---
4000	17	.---
6000	146	.064
8000	983	.418
9960	1956	.496

LFUID LEVEL 5640'

BY: R. K. McAnally

PRESSURE SERVICE

P.O. BOX 624

ELK GROVE, CALIFORNIA, 95624

A Line of Service

SUB-SURFACE SURVEY

OWNER ORE-IDA FOODS INC. FIELD WELL NAME ORE-IDA # 1

CASING 9-5/8" woth shoe 8183' ELEV. DATE: 11-24-79

LINER DESCRIPTION 7" 32# N-80 & C-95 hung 8142 to 10,038' ZERO POINT 22.5'

Liner perforated with shop cut slots 2" X 1/8" 16 slots per foot Depth 10,054

TUBING DETAIL @ ZONE

PUMP SHOE GAS ANCHOR INTAKE

PURPOSE Pressure survey run in tandem with temperature.

REMARKS Instruments run @ 20' a minute as close as possible in snow and wet line.

ELEMENT 5500 psi SERIAL No. 20561 CLOCK 24hour 15 TURN screw

ENGAGE STYLUS 2:20AM DISENGAGE STYLUS 6:55PM

OBS. TBG. PRESS. OBS. CSG. PRESS

COR. TBG. PRESS. COR. CSG. PRESS

PICKUP @ 9960' TIME ON BOTTOM 6:17AM TIME OFF BOTTOM 6:23AM

DEPTH	PRESSURE	DEPTH	PRESSURE	
6000	118	8183	1097	
6000	146	8310	1133	
6150	213	8420	1156	
6260	262	8560	1258	
6336	290	8700	1353	
6410	315	8740	1397	
6475	343	8830	1514	
6477	401	8885	1567	
6660	437	9040	1594	
6750	461	9150	1683	
6840	497	9240	1775	
6960	561	9355	1853	
7080	633	9471	1875	
7200	677	9615	1947	
7310	729	9700	1997	
7400	796	9775	2014	
7500	834	9850	2039	
7610	862	9960	2050	6 minutes on bottom.
7720	887	9960	2056	
7844	945			
7940	1000			
8045	1075			

R. K. McAnally

PRESSURE SERVICE

P.O. BOX 624

ELK GROVE, CALIFORNIA, 95624

A Line of Service

SUB-SURFACE SURVEY

OWNER ORE-IDA FOODS INC. FIELD WELL NAME ORE-IDA # 1

CASING 9-5/8" with shoe @ 8183' ELEV. DATE: 11-24-79

LINER DESCRIPTION 7" 32# N-80 & C-95 hung @ 8142 to 10,038' ZERO POINT 22.5'

Depth 10,054'

TUBING DETAIL @ ZONE

PUMP SHOE GAS ANCHOR INTAKE

PURPOSE Constant rate of travel 20' per minute survey from fluid level near 6000' to bottom

REMARKS Instruments in tandem #36394 & 20561

ELEMENT 125 to 350° F SERIAL No. 36394 CLOCK 24 15 TURN

ENGAGE STYLUS 2:30AM DISENGAGE STYLUS 6:50AM

OBS. TBG. PRESS. OBS. CSG. PRESS

COR. TBG. PRESS. COR. CSG. PRESS

PICKUP @ 9960' TIME ON BOTTOM 6:17AM TIME OFF BOTTOM 6:23AM

DEPTH	TEMPERATURE	DEPTH	TEMPERATURE	
6000	246.2	8183	284.2	
6150	246.6	8310	286.6	
6260	246.9	8420	287.4	
6336	246.9	8560	290.0	
6410	246.9	8700	297.0	
6475	247.6	8740	297.0	
6577	250.7	8830	292.6	
6660	253.4	8850	275.9	
6750	256.6	8885	306.3	
6840	258.5	9040	306.8	
6960	261.6	9150	315.4	
7080	262.8	9240	315.3	
7200	263.4	9355	316.0	
7310	264.5	9471	321.2	
7400	265.9	9615	330.2	
7500	267.9	9700	332.0	
7610	270.9	9775	338.9	
7722	273.0	9850	346.6	
7844	275.3	9960	355.6	) Instrument hung 6 minutes.
7940	278.3	9960	355.6	)
8045	281.6			

R. K. McAnally

PRESSURE SERVICE

P.O. BOX 624

ELK GROVE, CALIFORNIA, 95624

A Line of Service

SUB-SURFACE SURVEY

OWNER ORE-IDA FOODS INC FIELD WELL NAME ORE-IDA #1

CASING 9-5/8" with shoe 8183' ELEV. DATE: 11-25-79 11-26-79

LINER DESCRIPTION 7" 32# N-80 & C-95 hung 8142 to 10,038' ZERO POINT 22.5

Liner Perforated with shop cut slots 2" X 1/8" 16 slots to foot Depth 10,054

TUBING DETAIL Drill Pipe in hole prior to unloading with nitrogen ZONE

PUMP SHOE GAS ANCHOR INTAKE

PURPOSE To determine pressure and temperature prior to unloading well after perforating casing

REMARKS Tandem instruments #20561 and 36394

ELEMENT SERIAL No. CLOCK 24 hr 15 TURN screw

ENGAGE STYLUS DISENGAGE STYLUS

OBS TBG. PRESS. OBS. CSG. PRESS

COR. TBG. PRESS. COR. CSG. PRESS

PICKUP @ 9960' TIME ON BOTTOM 8:50PM TIME OFF BOTTOM 12:50

TIME	PRESSURE	TEMPERATURE
8:50	1956	356.6
9:50	2258	357.3
10:50	2308	357.0
11:50	2344	356.8
12:50	2389	356.7

R. K. McAnally

PRESSURE SERVICE

P.O. BOX 624

ELK GROVE, CALIFORNIA, 95624

A Line of Service

SUBSURFACE PRESSURE SURVEY

OWNER ORE-IDA FOODS INC. FIELD Wildcat - Onterio WELL NAME ORE IDA #1

CASING 9-5/8" with shoe 8183 ELEV. DATE: 11-26-79

LINER DESCRIPTION 7" Liner 32# N-80 & C-95 hung @ 8142 to 10038 ZERO POINT 22.5'

Liner perforated with shop cut slots 2" X 1/8" 16 slots per foot Depth 10054' TD

TUBING DETAIL None @ ZONE

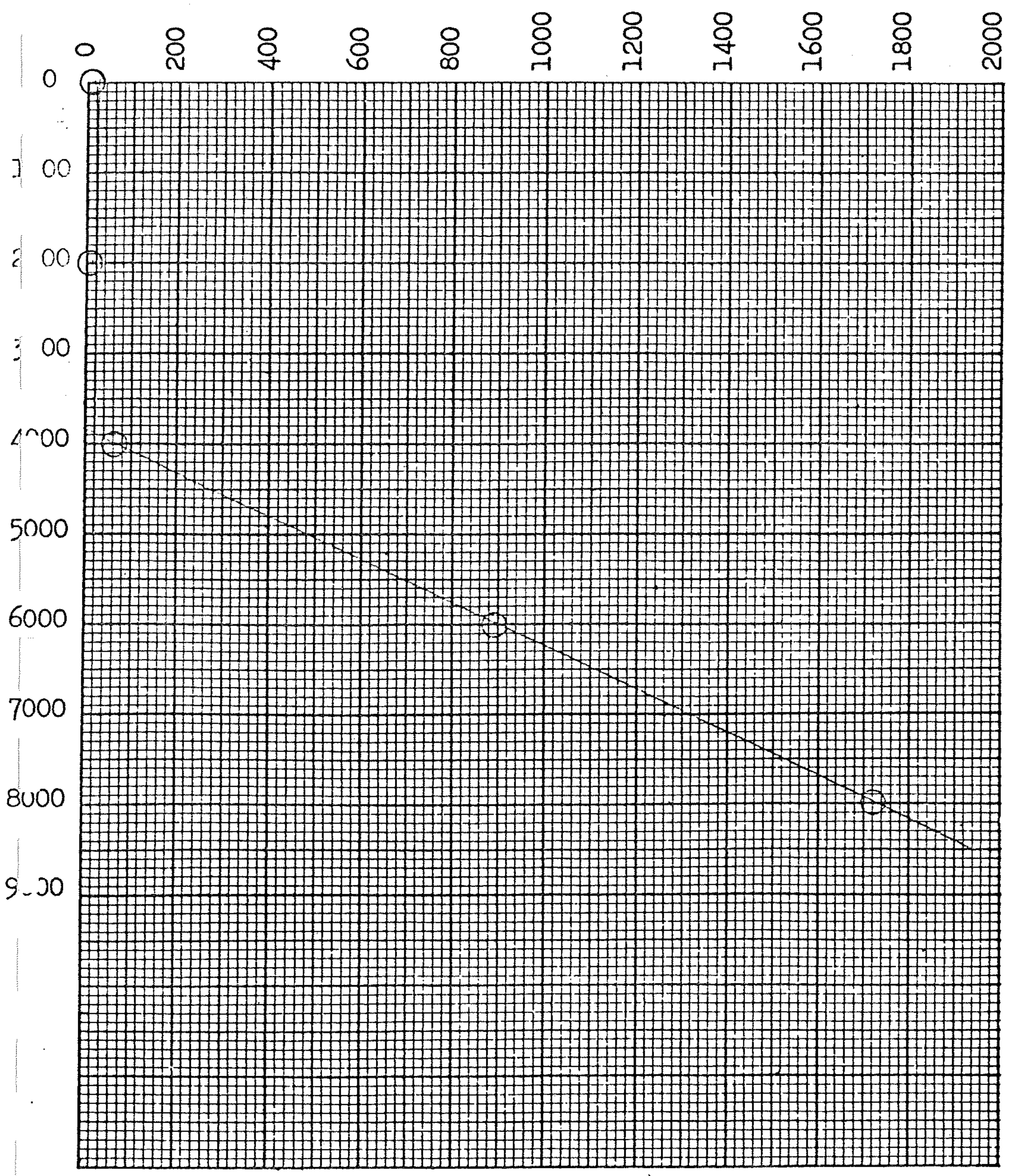
PUMP SHOE GAS ANCHOR INTAKE

PURPOSE Locate fluid level after blowing well from 8300' thru drill pipe with nitrogen.

REMARKS Pressure Instrument #42317 @ 3000 psi with 3 hour clock.

PICKUP @ MAXIMUM TEMPERATURE °F @

This run made after loosing tandem instruments by pulling wire from rope socket.



STABILIZATION PERIOD

GROSS OIL RATE B/D

NET OIL RATE B/D

FORMATION GAS MCF/D

GOR CFT/BBL.

CIRCULATED GAS MCF/D

OIL DRY GRAVITY °API

BEAN SIZE

CASING PRESSURE

TUBING PRESSURE

DEPTH	PRESSURE	GRADIENT
0	14	.---
2000	16	.001
4000	65	.024
6000	895	.415
8000	1725	.415

Fluid level 3860'

BY: R. K.. McAnally

TABLE J-3. MAXIMUM READING THERMOMETER DATA (OBTAINED WHILE RUNNING OTHER SURVEYS)

Survey	Date	Run	Time Since Last Circulation (hours)	Depth (feet)	Time on Bottom (minutes)	Maximum Temperature (°F)
Totco (GeothermEx)	8/25/79	-	1	3,151	45	126
Totco (GeothermEx)	9/ 3 /79	-	2	4,565	40	165
Totco (GeothermEx)	9/ 7 /79	-	10	5,212	40	192
Totco (GeothermEx)	9/10/79	-	7	5,805	60	200
Totco (GeothermEx)	9/12/79	-	7	6,200	30	230
Welex Dual Induction	9/18/79	1	11	7,150	--	236
Welex Fracture Finder	9/18/79	1	15	7,148	--	255
Welex Acoustic Velocity	9/18/79	1	19	7,148	--	264
Welex Density	9/19/79	1	29	7,150	--	302
Welex Dual Induction	10/ 1 /79	2	7-3/4	7,956	--	235
Welex Acoustic Velocity	10/ 1 /79	2	11-3/4	7,952	--	270
Welex Dual Induction	11/ 8 /79	3	13	10,053	--	320
Welex Fracture Finder	11/ 8 /79	3	15	10,047	--	368

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APPENDIX K

GEOCHEMISTRY OF FLUID SAMPLES

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GEOCHEMISTRY OF FLUID SAMPLES

Analyses of fluids from Ore-Ida No. 1 consist of five water samples collected sequentially during a flow test of the 5,980-8,340 interval on November 27, 1979. The results of analyses of these samples, four by AMTECh labs of San Diego, California, and one by AMOCO, are presented below in table K-1 through K-4, and plotted on a trilinear diagram as figure K-1. The AMOCO analysis does not include potassium (K) or silica (SiO_2). The samples received by the labs were a viscous, brown fluid, obviously containing abundant clay-sized particulates, plus traces of oil, both of uncertain source, and were not treated at the time of sampling to prevent loss by preciptation of such solutes as calcium and silica.

After completion of drilling and setting of a 7" slotted liner in the hole from 8,142 feet to 10,038 feet fluid in the hole was changed from drilling mud to fresh water to TD on November 14, 1979. The hole was blown with nitrogen to TD on November 16 and November 18, and loaded with 300 barrels fresh water to 8,977 feet? on November 19. After a shutdown, holes were shot in the casing between 5,980 feet and 8,340 feet on November 24, the hole blown with nitrogen to 8,350 feet on November 25, additional holes shot between 6,975 to 7,925 feet on November 26 and the hole blown with nitrogen again, to 7,950 feet, on November 27. It was during this last blow that the samples were collected. A subsequent pressure build-up survey from 4 a.m. to 7 a.m. with the instrument in the drill pipe at 7,900 feet showed that fluid rose from 6,855 feet to 6,091 feet during the survey, at a calculated rate of 13 gpm. Considering the condition of the samples as received by the labs and the well history, it is probable that they were contaminated to a moderate or considerable extent. Contaminants could include water added on November 19, as well as cement, drilling mud and associated fluids trapped behind the liner and casing and released by the numerous shots. The analyses indicate that added water was less of a contaminant than the drilling fluids. An additional effect on the samples would have been condensation and recirculation of vaporized fluid in the well-casing during the blow down test, which may have resulted in shifts in TDS due to dilution by or loss of steam. These events certainly would have affected dissolved CO_2 and pH levels, but in an uncertain direction.

The waters sampled are of sodium-mixed anion type, but are not uniform in composition. Samples 1 and 2, collected early during the flow test, have a total dissolved solids content of about 1,800 mg/l. Samples 3 and 4, collected later, have TDS of 3,700 to 3,800 mg/l, due

TABLE ..K-1..

CHEMICAL ANALYSES IN MG/L.:

ORE-IDA #1, FLUID SAMPLES
FROM FLOW TEST, 27 NOVEMBER, 1979

TABLE HEADINGS:
N=SAMPLE NUMBER. DATE=SAMPLE COLLECTION DATE, YR-MO-DAY. TC=TEMPERATURE IN DEGREES CENTIGRADE. PHF=FIELD PH. PHL= LAB PH. CA---CL=IONIC SPECIES, CONCENTRATIONS IN MG/L. SIO2=SILICA IN MG/L. TDSS=CALCULATED TDS. EC=CONDUCTIVITY AT 25 DEGREES, MICROMHOS/L. B=ATOMIC BORON IN MG/L. F---NO3=IONIC SPECIES, MG/L. (S=SULFIDE MG/L, LAB. H2SF=H2S MG/L, FIELD. CO2F=FIELD MEASUREMENT OF CO2, MG/L.)* COM=LINE NUMBER OF COMMENTARY TO THE ANALYSIS (IN SEPARATE TABLE). HYDCARB=freon extractable hydrocarbons.

NOTE: ALL 9'S MEANS NO DATA AVAILABLE. 0.0 MEANS BELOW DETECTION LIMIT OF ANALYSIS.

*not included

3/01/80 OIMANA;

N	NAME	DATE	TIME	TC	PHL	CA	MG	NA	K
1.0	ORE-IDA#1	791127	12:30AM	110	8.15	41.1	4.4	607.0	28.2
2.0	ORE-IDA#1	791127	12:40AM	128	8.28	38.8	3.7	564.0	27.2
3.0	ORE-IDA#1	791127	1:10 AM	150	9.02	69.6	12.4	900.0	101.0
4.0	ORE-IDA#1	791127	1:30 AM	125	8.24	70.3	17.2	904.0	69.5
5.0	ORE-IDA#1	791127	9999999	999	8.00	80.0	12.0	837.0	9999.9

N	LI	HCO3	CO3	SO4	CL	SIO2	TDSS	EC	B
1.0	0.60	800.0	0.0	332.0	259.0	135	1803	3258	32.80
2.0	0.65	820.0	0.0	353.0	258.0	144	1795	3123	20.00
3.0	0.70	586.0	67.2	1104.0	401.0	912	3858	5490	34.40
4.0	0.77	668.0	0.0	1061.0	373.0	854	3680	4960	28.20
5.0	99.99	805.0	0.0	875.0	355.0	9999	99999	99999	99.99

N	F	NO3	HYDCARB	COM
1.0	5.34	0.00	2.58	100
2.0	5.56	0.60	1.25	1000
3.0	4.55	0.70	1.78	1200
4.0	5.79	2.70	3.20	1800
5.0	99.99	99.99	999.99	2100

TABLE K-2

ANALYSIS IN MILLIEQUIVALENTS,
CALCULATED CONDUCTIVITY,
IONIC BALANCE,
IONIC RATIOS:

ORE-IDA #1, FLUID SAMPLES
FROM FLOW TEST, 27 NOVEMBER, 1979

TABLE HEADINGS:
N=SAMPLE NUMBER. CA THROUGH CL, F AND NH3*=CONCENTRATION IN MILLIEQUIVALENTS/L. B=CONCENTRATION IN MMOLES/L. ECOBS= MEASURED CONDUCTIVITY(LAB). ECCAL=CALCULATED CONDUCTIVITY. OBCA=ECOBS/ECCAL. SCAT=SUM OF CATIONS(MEQ/L). SAN=SUM OF ANIONS (MEQ/L). DIF=((SCAT-SAN)/(SCAT+SAN))*100. CAF=CA/SCAT. MGF= MG/SCAT. NKF=(NA+K)/SCAT. HCF=(HCO3+CO3)/(HCO3+CO3+SO4+CL). SOF=SO4/(HCO3+CO3+SO4+CL). CLF=CL/(HCO3+CO3+SO4+CL). CLF=CL/ (HCO3+CO3+SO4+CL). BCL=(B/CL)*100. FCL=(F/CL)*100. (NHCL= (NH3/CL)*100)* I=IONIC STRENGTH (CALC. WITH MOLAR CONCENTRA TIONS).

ALL 9'S MEANS NO DATA OR INSUFFICIENT DATA TO PERMIT CALCULATION

* NH_3 not included

3/01/80 DIMMEQ:

N	CA	MG	NA	K	HCO3	CO3	SO4	CL
1.0	2.05	0.36	26.39	0.72	13.10	0.00	6.91	7.30
2.0	1.94	0.30	24.52	0.70	13.43	0.00	7.35	7.28
3.0	3.47	1.02	39.14	2.58	9.59	2.24	22.98	11.31
4.0	3.51	1.41	39.31	1.78	10.94	0.00	22.09	10.52
5.0	3.99	0.99	36.40	999.99	13.18	0.00	18.22	10.01

N	B	F	NO3	ECOBS	ECCAL	OBCA	SCAT	SAN	DIF
1.0	3.034	0.281	0.000	3258	3102	1.050	29.527	27.314	3.89
2.0	1.850	0.293	0.010	3123	3045	1.026	27.459	28.051	-1.07
3.0	3.182	0.239	0.011	5490	5492	1.000	46.212	46.125	0.09
4.0	2.609	0.305	0.044	4960	5206	0.953	46.010	43.545	2.75
5.0	9.999	9.999	9.999	99999	99999	9.999	99.999	41.408	99.99

N	CAF	MGF	NKF	HCF	SOF	CLF	BCL	FCL	FSAN	I
1.0	0.07	0.01	0.92	0.48	0.25	0.27	41.54	3.85	1.03	0.033
2.0	0.07	0.01	0.92	0.48	0.26	0.26	25.43	4.02	1.04	0.033
3.0	0.08	0.02	0.90	0.26	0.50	0.25	28.14	2.12	0.52	0.061
4.0	0.08	0.03	0.89	0.25	0.51	0.24	24.80	2.90	0.70	0.058
5.0	9.99	9.99	9.99	0.32	0.44	0.24	99.99	99.99	99.99	9.999

TABLE ..K-3..

CHEMICAL GEOTHERMOMETERS

ORE-IDA #1, FLUID SAMPLES
FROM FLOW TEST, 27 NOVEMBER, 1979

TABLE HEADINGS:
N=SAMPLE NUMBER. GEOTHERMOMETERS--QTZC=QUARTZ CONDUCTIVE, QTZA=QUARTZ ADIABATIC, BCR=BETA CRISTOBALITE, CHAL=CHALCEDONY, AMOR=AMORPHOUS SILICA, SQ=SQR(CA)/NA, B43=NA-K-CA WITH B=4/3, B13=NA-K-CA WITH B=1/3, NKC=NA-K-CA VALUE OF CHIOCE, NAK=NA-K

CMG=MG-CORRECTED NKC, PCC=PCO2-CORRECTED NKC

R=FRACTION MG FOR CMG. DMG=MG-CORRECTION. C43 AND C13= PCO2-CORRECTED NKC WITH B=4/3 AND B=1/3.

PH=SAMPLE PH. HCO3=MEQ/L HCO3. PCO2=PARTIAL PRESSURE OF CO2 AT 25 DEGREES C. (PCO2=10↑7.82*(H+)*(HCO3)).

ALL TEMPERATURES IN DEGREES CENTIGRADE. ALL 9'S MEANS NO DATA OR GEOTHERMOMETER INAPPLICABLE.
REFERENCES: FOURNIER (1976, 1978 AND 1979), PACES (1975).

These values not equilibrium

3/01/80 OIMGTEMP;

N	QTZC	QTZA	BCR	CHAL	AMOR	SQ	B43	B13	NKC	NAK	CMG	FCC
1.0	155	147	55	130	33	1.21	148	157	157	126	120	999
2.0	159	151	59	134	36	1.27	146	158	158	128	126	999
3.0	314*	272*	231	323*	195	1.06	203	207	207	184	122	999
4.0	308*	267*	222	314*	187	1.07	182	185	185	157	85	999
5.0	9999	9999	9999	9999	9999	1.23	999	999	999	999	999	999

N	R	DMG	CMG	C43	C13	FCC	PH	HCO3	PCO2
1.0	11.5	36	120	999	999	999	8.15	13.10	0.0061
2.0	10.3	31	126	999	999	999	8.28	13.43	0.0047
3.0	14.4	85	122	999	999	999	9.02	9.59	0.0006
4.0	21.1	100	85	999	999	999	8.24	10.94	0.0042
5.0	99.9	999	999	999	999	999	8.00	13.18	0.0087

*Not valid. Silica geothermometers are defined only up to 250°C.

TABLE K-4

COMMENTARY TO THE ANALYSES.

```
OIMCOM@   3/02/80  17:30

 100  SAMPLE#1 COLLECTED DURING FLOW TEST 27 NOV. 1979.  LAB
 200  REPORTS THAT SAMPLE WAS VERY VISCOUS, OPAQUE BROWN,
 300  PROBABLY CONTAINED MUCH DRILLING FLUID OR FORMATION
 400  MUD (SAMPLES #2,3,4 ALSO THE SAME).  HYDCARB ARE FREON
 500  EXTRACTABLE HYDROCARBONS.  NOTE REPORTED CONDUCTIVITY
 600  (EC) IS AFTER DILUTION OF SAMPLE, TO GET BEST VALUE
 700  FOR COMPARISON WITH CALCULATED CONDUCTIVITY TO CHECK
 800  QUALITY OF ANALYSIS.
 850  NOTE: ANALYSES OF SAMPLES #1-#4 ARE BY AMTECH LABS, SAN DIEGO,
 860  CA (LAB REPORT #0831-79, JAN.11, 1980 ).
 900  ---
1000  SAMPLE #2, SEE COMMENTS ABOVE.
1100  ---
1200  SAMPLE #3.  SEE COMMENTS ABOVE.  LAB CONFIRMS HIGH
1300  SIO2 (MEASURED BY ATOMIC ABSORBTION), NOTE THAT SAMPLE
1400  WAS NOT DILUTED IN FIELD AT TIME OF COLLECTION, SOME
1500  SIO2 COULD HAVE BEEN LOST BY PRECIPITATION AND REMOVAL
1600  BY FILTERING TO PREPARE SAMPLE FOR ANALYSIS.
1700  ---
1800  SAMPLE #4.  SEE COMMENTS FOR #3 AND #1.  LAB AGAIN
1900  CONFIRMS HIGH SIO2.
2000  ---
2100  SAMPLE#5.  ANALYSIS BY AMOCO OF SAMPLE COLLECTED DURING
2200  SECOND FLOW TEST, 5980-8340 INTERVAL (SAME AS FOR #1-
2300  #4 ABOVE).  CL REPORTED AS 150 MG/L IN WATER ADDED TO
2400  HOLE BEFORE TEST.  SAMPLE RESISTIVITY 2.25 OHM-M @ 77DEG.
2500  F., SP.GRAV.=1.003 @ 70DEG.F, TOTAL SOLIDS BY EVAP.=
2600  3520 MG/L, NACL RESISTIVITY EQUIV.=1.935 MG/L.
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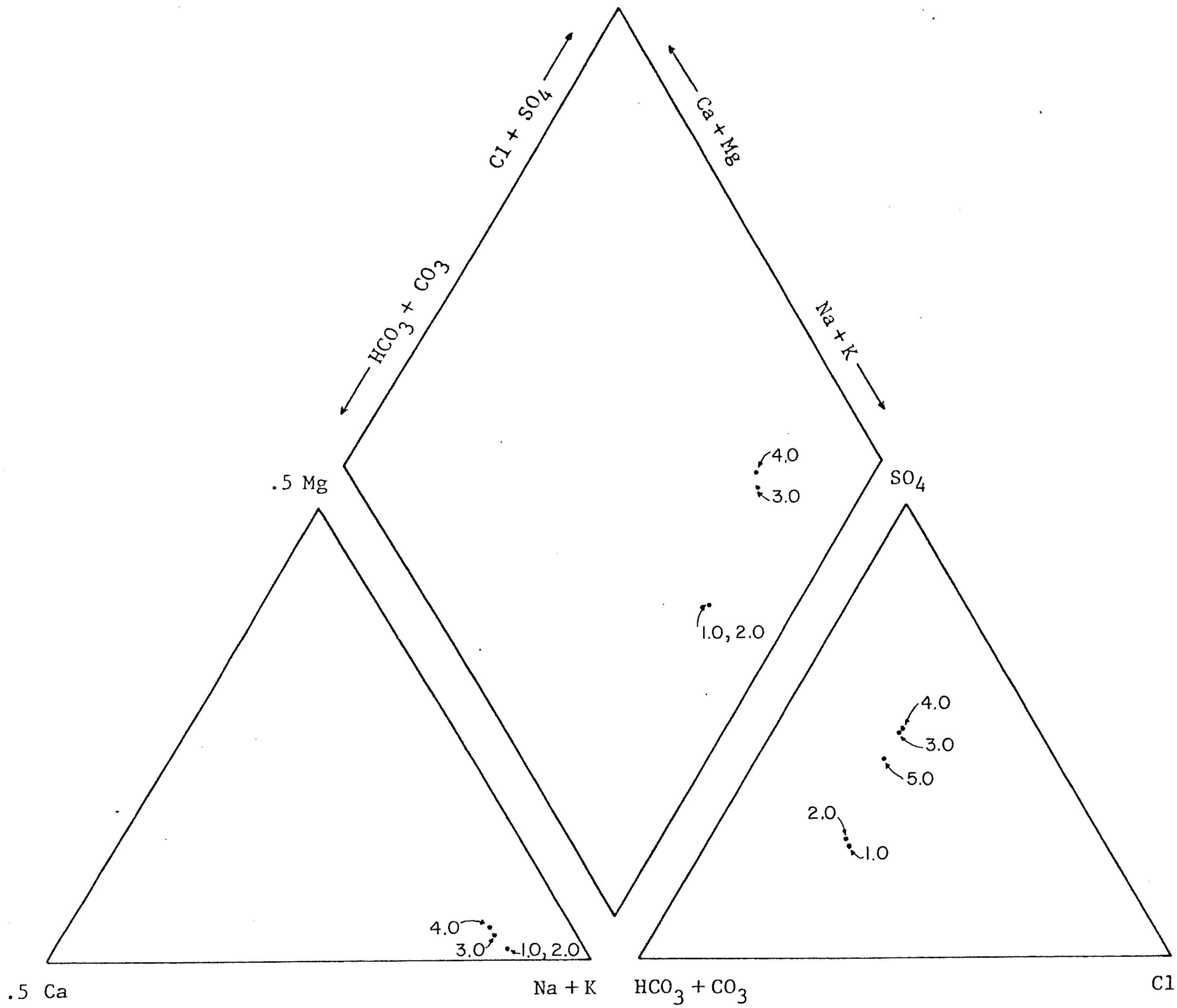

FIGURE K-1. Trilinear diagram of fluid sample compositions, Ore-Ida No. 1 flow test, November 27, 1979.

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to greatly increased concentrations, primarily of sodium, sulfate, and silica. The time of collection of sample 5 is unavailable, but its composition suggests collection between samples 2 and 3.

The cause of the composition shift may be either a progressive cleaning from the well of drilling fluid (make-up water, solutes from drilling mud and chemicals), or it may be a shift in production zones (horizon levels) during the test. As the minor solutes lithium, boron, fluoride and nitrate are all nearly or totally as concentrated in the earlier samples as in the later ones, it seems unlikely that the shift could be due to a change in dilution by drilling fluid.

Samples 3 and 4 have extremely high silica contents of 912 and 854 mg/1. The samples were analyzed simultaneously with numbers 1 and 2 and the laboratory has reviewed and confirmed the results. Therefore, the analyses may be reliable and at the least indicate very high dissolved silica concentrations. Silica, along with all other solutes, may have been concentrated by boiling in the well bore during the test. Conversely, some silica may have been lost by precipitation during storage prior to analysis, since no dilutions were made at sampling time. The observed concentrations exceed the maximum known solubility of quartz in pure water at any temperature (725 mg/1 and 330°C/626°F). Data for the solubilities of cristobalite and chalcedony are available only to 250°C/482°F and also are less than the observed concentrations.* The solubility of amorphous silica reaches the observed levels at about 190°C/375°F. This is somewhat above the maximum temperature of about 168°C/335°F, logged by temperature surveys of the well, but equal to the maximum of 187°C/370°C measured with a maximum reading mercury thermometer lowered down hole. Neither of these were equilibrium temperatures, which at 8,000 feet may be about 350°F and at 10,000 feet about 420-425°F. In rocks at the depths and temperatures indicated, it is likely that any silica deposited in an amorphous state such as volcanic glass would have already become crystalline. The high concentrations may be due to solution of silica from an amorphous source at more moderate temperatures, followed by concentration by boiling, or may be spurious due to sample contamination or analytical error.

Application of the cation (Na-K-Ca) geothermometer gives temperatures of about 160°C/315°F for samples 1 and 2 and 185° to 210°C/365°F to 405°F for samples 3 and 4 (table K-3, column NKC). The average of

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*Fournier, R. O. and Rowe, J. J., 1966, Estimation of Underground Temperature from the Silica Content of Water from Hot Springs and Wet-Steam Wells, <u>Am. Jour. Sci.</u>, 264, 685-697.

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these is 350°F and equal to the projected equilibrium temperature at 8,000 feet. The tested zone which could have produced fluids extended only to 8,340 feet. Application of the Mg-correction to the cation temperature lowers the estimates to about 85° to 125°C/185 to 250°F (table K-3, column CMG), which is probably an over-correction, as sample temperatures are reported to have been in the range 110°C to 150°C/230°F to 300°F. These temperatures were doubtlessly lower than temperatures in production zones down-hole.

Considering that the condition of the samples as collected and received by the labs indicates some sort(s) of impurity and possible loss of calcium in addition to the possibilities of mixing of fluids from different depths and contamination from drilling fluid, the rock formation temperature estimates provided by the cation geothermometer can be considered to be good. Longer term flow tests are required for more reliable samples.

Twelve waters from wells and springs in the Ontario, Payette and Weiser areas have been described in the report "Data Analysis and Drilling Site Selection for Ore-Ida Property, Ontario, Oregon" by GeothermEx, Inc., October 1978. The samples from Ore-Ida #1 are distinct, having for example higher TDS, much higher Na and Na/Ca, usually lower Mg, higher HCO_3, SO_4 and Cl, and higher SiO_2. Several of the shallow waters have SO_4 approaching the levels in samples 1 and 2 from Ore-Ida #1, and above Cl, but the limited similarities are too slight to indicate any connection between the deep and shallow fluids.